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IMPERFECT TRANSPARENCY AND THE STRATEGIC USE OF INFORMATION: AN EVER PRESENT TEMPTATION FOR CENTRAL BANKERS?

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Most economists argue that transparency in monetary policy is desirable because it helps the private sector make better informed decisions. They also argue that a lack of transparency has been a key problem in Europe's monetary policy. Using standard models—where there are also opportunities to use fiscal policy—we show that a lack of transparency will have very different effects depending on whether it represents a lack of *political* transparency or a lack of *economic* (or information) transparency. The former allows the central bank to create and exploit a 'strategic' reputation to its own advantage. The latter does not. Thus, political transparency helps us understand *how* monetary policy decisions are made. But economic transparency would reveal *what* information went into those decisions.

1 Introduction

Most economists agree that greater transparency in monetary policy decisions is desirable because it allows the private sector to make better, i.e. welfare improving, decisions, as well as better informed decisions (Blinder, 1998). But not all agree with this point of view.

Some argue that incomplete transparency is optimal, as the effect on the central bank's reputation and its consequent ability to control inflation effectively has to be balanced against the private sector's wish to see output, employment and prices stabilized. Statements of this kind can be found in Svensson and Faust (2002) or Jensen (2002). Others argue that certain restrictions on transparency are also important for operational reasons. Once again the idea is to reinforce the bank's credibility, and to separate out 'the need to know' from 'the need to understand' (Issing, 1999; Padoa-Schioppa, 2000).

In practice, most central banks have actually increased their transparency in recent years—using inflation forecasts, extensive explanations of the reasoning behind their decisions, and sometimes voting records on policy

* We are grateful for many clarifying comments from Petra Geraats and Maria Demertzis.

decisions or a discussion of the policy 'bias' to do so. Prominent examples are found in the Federal Reserve System in the USA, but also in the Bank of England and the central banks of Canada, New Zealand and Sweden. The most distinguished counter-example lies in the European Central Bank (ECB), which was moved to limit the degree of transparency in its policies. It is significant that the ECB is the most independent of the major central banks, and also the one most concerned with the importance of policy credibility and with the need to separate the issue of control ('the need to know') from oversight of the policy rules themselves ('the need to understand').

The problem here is that transparency has many dimensions and therefore means different things to different people (Eijffinger and Geraats, 2002). Kuttner and Posen (2000) list the different characteristics which are necessary for institutional transparency:

- a numerical goal for monetary policy,
- an inflation report, explaining the expected effects of changes in monetary policy,
- an inflation forecast (plus assumptions) explaining why those changes were necessary and
- a post-mortem evaluation of past policies and their achievements.

These attributes cover both the information content and the way in which that information has been used. That distinction is important, but is seldom made.[1] The distinction itself relates directly to the conflict between the ability to control and the need for transparency. As a result, many commentators reach opposite conclusions about the need for transparency. Kuttner and Posen (1999) argue that it will enhance the central bank's ability to use discretionary policies, while Svensson and Faust (2002) conclude the opposite. Both sets of authors argue that transparency will reduce the noise and the imprecision in the private sector's decision-making. But they differ as to whether greater transparency would increase the ability of the central bank and private sector to make consistent decisions, or reduce the central bank's ability to control the private sector's natural tendency to avoid monetary discipline.

The purpose of this paper is to review the issues which imperfect transparency in monetary policy raises. A lack of transparency is said to arise when the central bank has private information about the nature of the shocks *and* the way in which policy affects the economy (Cukierman, 1992, 2000); or when the central bank has not stated its objectives clearly (Cukierman and Meltzer, 1986); or when the public is uncertain about the preferences of the

[1]See the discussions in Friedman (1997), Bomfin and Reinhart (2000) or Sheffrin (1998).

central bank (Muscatelli, 1998; Nolan and Schaling, 1998; Eijffinger *et al.*, 2000). In each of these cases, a lack of transparency introduces a disturbance which distorts the private sector's expectations for inflation. This provides an automatic link both to the strategic use of that information and to the desire to ensure accountability.[2] Our conclusions therefore turn on the difference between knowing what information is being used, compared to knowing how that information will be used.

Stylized facts point to the same distinction. Critics of the ECB's policies, both in the markets and in the academic debate, have called for the publication of inflation forecasts, transcripts of the process by which decisions are reached, voting records (or 'bias' statements) and clearer priorities for future policies, i.e. all the things that fall under the 'need to understand' heading. The importance that the private sector attaches to these factors is clear. Asked to rank their understanding of their own central bank's monetary decisions on a scale of 1 to 5, Goldman Sach's clients gave the Federal Reserve a score of 4.3, the Bundesbank and the Bank of England 3.5 and 3.3 respectively, but the ECB only 2.2.[3] Our contribution to this debate is to stress the difference between *political* transparency (where policy preferences, or relative priorities, are clearly articulated for all to see) and *economic* transparency (where the external information, control errors or target values are made clear). That is to distinguish between understanding how the policy rule works, and knowing what conditioning information has been used in that rule.

2 Fiscal and Monetary Policies with Full Transparency

2.1 The Model

We start with the standard analysis of Barro and Gordon (1983), Rogoff (1985) and Debelle and Fischer (1994). We suppose that the government delegates the conduct of monetary policy to an independent central bank, which optimizes period by period with preferences at least as conservative as the rest of society. Suppose also that the government is able to keep control of its fiscal instrument. The central bank's problem is then to minimize the loss function

$$L_{\mathrm{CB}} = \tfrac{1}{2}\left[\pi^2 + \tau^2 + \gamma(y-k)^2\right] \tag{2.1}$$

subject to

$$y = \pi - \pi^{\mathrm{e}} - \tau + \varepsilon \tag{2.2}$$

[2]See King (1997), Eijffinger *et al.* (2000) and de Haan and Eijffinger (2000).
[3]*Financial Times*, 7 March 2000.

where y is output (with target level $k \geq 0$),[4] π is inflation (with expected value π^e but a target level of zero), τ is tax revenues *net* of expenditures[5] and ε is a random shock with zero mean. The bank's policy instrument is its choice of π. Finally γ is the relative priority placed on the output target. It is therefore an index of conservatism (smaller γ values) or liberalism (larger γ values).

Our aggregate supply function (2.2) takes the same form as the supply functions already popularized in this literature (Barro and Gordon, 1983; Debelle and Fischer, 1994; Alesina and Gatti, 1995). Implicit in its structure is a sequence of events which gives our problem a two-period dynamic structure. Wages will actually be set ahead of the determination of y. This means that π^e is the inflation rate which wage-setters and the private sector expect, at the beginning of the period, to hold at the end of that period (Roberts, 1995). As such it incorporates the microfoundations of monopolistic competition, staggered wage–price setting as in Calvo contracts and quadratic adjustment costs. Optimal wage contracts would then produce a relationship like (2.1): Rotemberg and Woodford (1998).

The central bank's optimal reaction function is now obtained by inserting (2.2) into (2.1) and optimizing with respect to π. We get

$$\pi = \frac{\gamma}{1+\gamma}\left(\pi^e + \tau + k - \varepsilon\right) \tag{2.3}$$

The fiscal authorities, meanwhile, aim to minimize the private sector's loss function

$$L_{FA} = \tfrac{1}{2}\left[\pi^2 + \tau^2 + \beta(y-k)^2\right] \tag{2.4}$$

subject to (2.2).[6] The government's instrument is τ, with optimal reaction function[7]

$$\tau = \frac{\beta}{1+\beta}\left(\pi - \pi^e + \varepsilon - k\right) \tag{2.5}$$

[4]Output is measured in deviations from its long-run full-capacity level y_c. It is important to note that the inclusion of τ in (2.1) will have no influence on the central bank's first-order conditions. We have included τ here only because many central banks appear to be very concerned about the fiscal stance of their governments—even though they cannot affect fiscal policy themselves.

[5]Like Debelle and Fischer (1994) and Nordhaus (1994), we do not include an explicit budget constraint in our model. Instead we constrain fiscal policy by placing *explicit* penalties on the use of fiscal policy by the fiscal authorities—see (2.4) below. Standard theory would then produce a feedback rule which satisfies the sufficient conditions required for long-term solvency and the 'cash in advance' constraint (Canzoneri *et al*., 2001) and which endogenizes expenditures and the financing costs. Consequently, we do not need to report the components of the budget constraint or debt separately.

[6]If, following Rogoff's arguments, the central bank should be at least as conservative as the government, then $\gamma \leq \beta$. Demertzis *et al*. (1999) show that the electoral mechanism will typically deliver exactly that result.

[7]Note that (2.5) is invariant to changes in the parameter (of unity) on τ in (2.4).

Substituting (2.5) into (2.3) for a Nash equilibrium reveals expected inflation to be

$$\pi^{e} = \frac{\gamma}{1+\beta} k \tag{2.6}$$

Consequently the equilibrium choices for inflation (monetary policy) and net tax revenues are

$$\pi^{*} = \frac{\gamma}{1+\beta} k - \frac{\gamma\varepsilon}{1+\beta+\gamma} \tag{2.7a}$$

$$\tau^{*} = \frac{-\beta}{1+\beta} k + \frac{\beta\varepsilon}{1+\beta+\gamma} \tag{2.7b}$$

Thus $E(\pi^{*}) > 0$, reflecting the inflation bias in (2.7a), and $E(\tau^{*}) < 0$. Finally one might question the presence of $k \neq 0$ among the central bank's objectives. It is a fact that all models in this literature include such an objective, and always for the same reason.[8] Taxes and supply side restrictions are distortionary in the sense that they depress output and employment by more than surprise inflation can improve them. Similarly labour market imperfections, imperfect competition and job protection schemes will also keep real wages above their market clearing levels, and output below its first best optimum (Persson and Tabellini, 1990). We therefore need to set $k \geq 0$ to correct for any of those distortions.

Finally solutions where the bank is fully precommitted to a certain inflation control rule (see McCallum, 1997), or where fiscal policy has only temporary effects on y, may also be fitted into this framework as a special case—see Demertzis *et al*. (1999) for details. We do not report separate results for these cases.

2.2 Definitions of Transparency

2.2.1 Political Transparency. To define full transparency, we need to start from a general specification in which the central bank attaches explicit weights to both its objectives. It is important to define transparency in its most general form, and only then impose normalization restrictions, in order to account for all relevant information. Consider a central bank which assigns positive numbers a and b as the relative priorities on reaching its policy targets:

$$E(L) = \tfrac{1}{2} E\left[a\pi^{2} + b(y-k)^{2}\right] \tag{2.8}$$

This is just a simplified version of (2.1) to illustrate a particular point. Nevertheless, in identifying this loss function, what we are actually interested

[8]See Barro and Gordon (1983), Rogoff (1985), Debelle and Fischer (1994), Alesina and Gatti (1995) and McCallum (1997).

in is not the value of each of the parameters a and b *per se*, but the relative weight attached to the two objectives b/a, and therefore the marginal rate of substitution between them: $(b/a)(\Delta\pi/\Delta y)$. The issue of transparency arises whenever the public's perception of the bank's preferences, e.g. on output (β), differs from the values that the bank itself actually considers (b). We define this discrepancy as $\beta = b + \eta$, where η is a random error (made by the private sector) with $E(\eta) = 0$ and $V(\eta) = \sigma_\eta^2$. This formulation implies that the public is correct on average, but may be mistaken when making guesses about preferences in individual cases or at specific points of time. But uncertainty about b implies that the public perception about the relative importance that the central bank attaches to controlling inflation is also open to error. To show this, we rescale the sum of the two parameters to equal a constant, say $a + b = 1$.[9] This helps define the public's uncertainty about the true value of a in terms of η: i.e. $\alpha = a - \eta$ and therefore $E(\alpha) = a$. However, $E(\eta) = 0$ is not sufficient to define transparency itself. Full transparency would also require that the ratio of the two parameters, as perceived by the public, should equal the ratio of the true values on average. This is not achieved by the assumptions made so far since the expectation of a ratio is not the ratio of the expectations. To see this, note that the perceived relative weights are

$$\frac{\beta}{\alpha} = \frac{b+\eta}{a-\eta} \tag{2.9}$$

where full transparency requires

$$E\left(\frac{\beta}{\alpha}\right) = \frac{b}{a}$$

But

$$\frac{\beta}{\alpha} = \frac{b+\eta}{a-\eta} = \frac{b}{a} + \xi \tag{2.10}$$

where

$$\xi = \frac{(a+b)\eta}{a(a-\eta)}$$

and

$$E(\xi) = E\left[\frac{(a+b)\eta}{a(a-\eta)}\right] = \frac{(a+b)\bar{\eta}}{a(a-\bar{\eta})} - \frac{(-a)(a+b)\sigma_\eta^2}{a^2(a-\bar{\eta})^2} + \frac{a^2(a+b)\bar{\eta}}{a^3(a-\bar{\eta})^3}\sigma_\eta^2 \tag{2.11}$$

We can now see that the assumption $E(\eta) = 0$ is not sufficient since full transparency also requires $E(\xi) = 0$. If we impose $E(\eta) = 0$ alone, it implies that

[9]See Beetsma and Jensen (1998), for example.

$$E(\xi) = \frac{(a+b)\sigma_\eta^2}{a^3} \tag{2.12}$$

and hence that $E(\beta/\alpha) \neq b/a$. In this case, the central bank could not deliver full transparency even if it wanted to—*unless* it also provided the private sector with full information ($\sigma_\eta^2 = 0$) at the same time. Hence, we have the following definition.

Definition 1: Full political transparency occurs if $E(\eta) = 0$ and σ_η^2 both hold.

Note that the objective function we will be using below assumes $a = 1$.[10] This is a convenient simplifying assumption. It does not change any of the qualitative results we present since the conditions for transparency do not change. Following this definition, public perceptions and central bank preferences are related through $\beta = b + \eta$ where η has the properties defined above. This implies that the public will on average anticipate the correct preference parameter, i.e. $E(\beta) = b$, but for full transparency to hold we need $\sigma_\eta^2 = 0$ as well.

2.2.2 Economic (Goal) Transparency. We also consider a different form of transparency, this time relating to the public being uncertain about the value of k that the central bank targets (the control errors approach of Cukierman (2000), Geraats (2002), Jensen (2002) and Faust and Svensson (2001)). We identify this with economic transparency. Suppose the central bank actually targets k, but the public anticipates $c = k + v$ where v is an error with $E(v) = 0$ and $V(v) = \sigma_v^2$. As a consequence, $E(c) = k$.

Definition 2: Full economic transparency occurs when conditions $E(v) = 0$ and $\sigma_v^2 = 0$ both hold.

This time transparency is indexed by the variance of v, and full economic transparency is identified with $\sigma_v^2 = 0$. Note that k would typically contain all the conditioning information that goes into an inflation forecast—exogenous factors, decisions by other players, forecasts of random events[11] and target values set by the domestic policymakers.

[10]This is the normalization adopted in most studies of transparency: see the papers by Cukierman (2000), Sibert (2002) or Muscatelli (1998).

[11]In other words, any *systematic* information that the central bank may have on ε is assumed to have been incorporated into k (Walsh, 2002). But whether the bank will choose to reveal that information is the subject of Section 4. Canzoneri (1985) argues that the credibility of the bank's policies may fall apart if its forecasts are private information because wage-setters cannot tell if the bank is performing as promised—because, even taking into account the different forms of information uncertainty, the bank's forecasts will be related to k. The bank may then have an incentive to misrepresent. Canzoneri suggests certain rules to overcome this difficulty. But as we see in Section 4.2, this is unlikely to be a major issue.

3 Imperfect Transparency over Priorities

Suppose now that the private sector is uncertain about the bank's true priority for inflation control relative to its priority for stable output and employment. This implies a lack of transparency about how the bank will make its decisions, but not about the bank's target values for inflation or output, or the conditioning information more generally. For the moment we take those target values to be known.

3.1 The Intended Decisions under Private Information

Suppose private sector agents believe the central bank will use $\overline{\gamma}$ in (2.1), whereas the bank actually decides to use γ_1. Suppose too the private sector has a distribution of beliefs about the values of γ_1 that might be used:

$$\gamma_1 = \overline{\gamma} + \eta \tag{3.1}$$

where η is a random variable distributed between $-\overline{\gamma}$ and ∞, with mean zero and variance σ_η^2. The bank, by contrast, knows the value of γ_1 it will use. It also knows the mean of the private sector's distribution: $\overline{\gamma}$. In that sense the central bank has private information.[12]

Since (2.2) refers to the economy's supply responses, π^e must represent the private sector's expectation for inflation—conditional on the private sector's information set. This means the private sector will need to solve $\min_\pi E(L_{CB/PS})$ subject to (2.2)[13] in order to evaluate π^e and the decision rules it expects to determine π and τ. We get

$$\pi^e_{PS} = \frac{\overline{\gamma} k}{1+\beta} \tag{3.2}$$

with

[12]An alternative formulation would be the 'constructive ambiguity' approach of Cukierman and Meltzer (1986) and Balke and Haslag (1992). This involves constructing time-varying random preference parameters with persistence, to represent changing and partly uncertain priorities for output stabilization versus monetary control. However, this is done through a linear term in the central bank's objective function; and since a linear term is equivalent to a shift in the target value for the corresponding variable in the quadratic term (Hughes Hallett and Rees, 1983), this approach is formally equivalent to making k time varying and uncertain. We deal with that case in Section 4. Nevertheless, we should note that imperfect transparency may still be left in the problem because of the costs of gathering information on the bank's true intentions, and because variability in monetary policies will increase the desire to uncover those intentions. On the other hand, the bank may want to preserve some ambiguity because it allows the bank to operate 'opportunistically', i.e. sharpen the timing of its actions (surprise inflation in slumps, tighter policies in booms), just as Blinder (1997) has argued.

[13]From now on we write $L_{i|j}$ to denote the objective function of player i evaluated conditional on the information set of player j. And, in order to keep things simple, we will assume that the private sector and the fiscal authorities share information sets.

$$\pi^*_{PS} = \frac{\overline{\gamma}k}{1+\beta} - \frac{\overline{\gamma}\varepsilon}{1+\beta+\overline{\gamma}} \tag{3.3a}$$

and

$$\tau^*_{PS} = \frac{-\beta k}{1+\beta} + \frac{\beta\varepsilon}{1+\beta+\overline{\gamma}} \tag{3.3b}$$

By contrast, the bank's preferred outcomes appear to be

$$\pi^e_{CB} = \frac{\gamma_1}{1+\beta}k$$

with

$$\pi^*_{CB} = \frac{\gamma_1 k}{1+\beta} - \frac{\gamma_1\varepsilon}{1+\beta+\gamma_1} \tag{3.4a}$$

and

$$\tau^*_{CB} = \frac{-\beta k}{1+\beta} + \frac{\beta\varepsilon}{1+\beta+\gamma_1} \tag{3.4b}$$

from which we get the expected outcome of the bank's preferred policies as π^e_{CB}. Hence the private sector's expectations differ from the central bank's preferred value by a stochastic term:

$$\pi^e_{PS} - \pi^e_{CB} = \frac{-k\eta}{1+\beta} \tag{3.5}$$

But there can be no systematic difference if the private sector has rational expectations—at least, not in the long run. On the other hand, short-run 'errors' are possible, and could be exploited as long as γ_1 remains unknown. And long-run errors are also possible, but only if the private sector is subject to bounded rationality or persistent information 'biases', i.e. only if the conditions for an unconditional rational expectations equilibrium obtain: Fagin *et al*. (1995). Nevertheless, the private sector will eventually realize that the final outcomes will emerge from a solution which combines the bank's optimal reaction function (2.3), the optimal fiscal reaction function (2.5) and the expected inflation rate π^e which those two imply. Substituting (2.5) into (2.3) and taking expectations shows that both π^* and π^e are non-linear in the unknown (to the private sector) random value γ_1 which the bank will use for γ. That is, (2.5) in (2.3) implies

$$\pi^e = E\left(\frac{\gamma_1 k}{1+\beta+\gamma_1}\right) \Big/ \left[1 - E\left(\frac{\gamma_1}{1+\beta+\gamma_1}\right)\right] < \frac{\overline{\gamma}k}{1+\beta} \tag{3.6}$$

where we have used Jensen's inequality when $\overline{\gamma} = E\gamma_1$ is substituted for γ_1. Hence there is no exact closed-form solution to the private sector's problem

because it is not possible to determine an exact solution for $E[\gamma_1/(1+\beta+\gamma_1)]$ in terms of the parameters of the underlying probability distribution. However, that does not mean that no solution exists; only that it cannot be written down explicitly. If nothing else, agents could compute π^e numerically. But because that will be costly (Balke and Haslag, 1992), and may be fragile if conditions change, agents are likely to use an approximate value. And the fiscal authorities could do the same. However, if the private sector uses $\bar{\gamma}$ in (3.6) as part of a first-order certainty-equivalent approximation[14] to the solution for π^e, there will be a systematic error as indicated by the inequality in (3.6). And, since the private sector may never obtain an exact solution for π^e unless the value of γ_1 is revealed, this error could persist even if the private sector refines its estimate of $\bar{\gamma}$ as the mean of the γ_1 distribution. In that case, we will be condemned to remain in a boundedly rational equilibrium whether we like it or not.[15]

Thus, if there is any reason to maintain this lack of transparency for strategic purposes, the one thing the central bank cannot do is publish its inflation forecasts. If it did so, γ_1 would immediately be revealed and any advantages that might flow from maintaining confidentiality about the bank's policy intentions—such as those presented in Issing (1999), or those discussed in Sections 3.2 and 3.3 below—would be lost.

3.2 From Intentions to Actual Outcomes

The actual outcomes will be different from (3.3) or (3.4), however, since the private sector's information will go into the determination of π^e and the choice of τ^*, but the central bank's information goes into determining π^*. Inserting (3.2), as the private sector's first-order certainty-equivalent approximation for π^e, into the Nash equilibrium defined by (2.3) with γ_1 and (2.5) for the central bank's decisions, and by (3.3b) as the fiscal authorities' chosen policy rule, we get

[14]See Theil (1964). In fact it is rather easy to show that the error in using first-order certainty equivalence is almost certainly small: less than 10 per cent of the 'true' expected inflation rate on any reasonable assumptions for the underlying parameters (see Appendix A for details). Thus, if the private sector is led to expect an inflation rate of approximately 2–3 per cent, the true expectation should have been a little above 1.8–2.7 per cent. That means there is really very little incentive either for the private sector to make their expectations more accurate (especially if it costs a lot to do so) or for the central bank to revise and refine their monetary policy decisions on the basis of the true expectations revealed by (3.6)—given that (2.2) shows that output reacts to expectations in the market, not to what the central bank may think.

[15]This means it would be impossible to get a full rational expectations equilibrium when one player is forced, through incomplete information, to make a series of approximation errors—unless the private sector finds it worthwhile to employ a learning algorithm which is able to fit values of γ_1 such that the private sector's calculation of π^e converges (eventually) onto the mean of the inflation outcomes actually experienced.

$$\pi^* = \frac{\gamma_1}{1+\beta}\left(\frac{1+\beta+\bar{\gamma}}{1+\beta+\gamma_1}\right)k - \frac{\gamma_1\varepsilon}{1+\beta+\gamma_1} \tag{3.7}$$

and

$$\tau^* = \frac{-\beta k}{1+\beta} + \frac{\beta\varepsilon}{1+\beta+\bar{\gamma}} \tag{3.8}$$

as the actual outcomes. They differ from the bank's intended position only in the term in parentheses in (3.7). That term is positive but less than unity if $\gamma_1 > \bar{\gamma}$. Hence, by choosing $\gamma_1 > \bar{\gamma}$, the bank can reduce inflation on average—but at a cost to the variability of inflation (the variance of π^* is increasing in γ_1). That provides a possible incentive for the bank to strategically misrepresent its own preferences.

However, there is no change in the average deficit τ^*—either from what the bank might have chosen for itself, (3.4b), or from what the private sector had expected, (3.3b). The only change is that the deficit shows a higher variability in (3.8) than in (3.4b).[16] That is the tradeoff inherent in misrepresenting ones' preferences: lower inflation, but more active fiscal policies. Since the central bank will realize that it can achieve better results with less than full transparency, but at the cost of less fiscal stability then it might wish, these results help explain the usual central bank rhetoric and frustration over the fiscal authorities' apparent lack of fiscal discipline.

3.3 Will the Bank Use its Lack of Transparency Strategically?

The upshot of these results is that inflation may be lower on average, but more volatile than the private sector had expected. However, the fiscal deficit will be no smaller, and it will be used more aggressively. As a result, it is not clear that the central bank would actually want to use this lack of transparency strategically. The opportunity is there. But whether this tactic actually produces more stable output, and an unambiguous incentive for the bank to misrepresent its preferences, remains to be seen. If it does, then we have a plausible model of the ECB during its first four years: conservative monetary policies and strong rhetoric, but little attempt to explain those policies.

Inserting (3.2) and (3.3), or (3.2), (3.7) and (3.8), into (2.2) yields

$$y^*_{PS} = \frac{\beta k}{1+\beta} + \frac{\varepsilon}{1+\beta+\bar{\gamma}}$$

and

$$y^* = \left(\frac{\beta}{1+\beta} + \frac{\eta}{1+\beta+\gamma_1}\right)k + \left[1 - \frac{\eta(1+\beta)}{1+\beta+\gamma_1}\right]\frac{\varepsilon}{1+\beta+\bar{\gamma}}$$

[16]Recall that $\tau < 0$ represents a deficit. Equation (3.8) shows greater variability than (3.4b) since $\gamma_1 > \bar{\gamma}$ is the condition required for lower inflation on average.

which means that the central bank and the private sector both expect the same level of output if ε and η are uncorrelated. But they would expect a higher level of output volatility even so. And any countercyclical policies, if η and ε were negatively correlated, would destabilize output. Thus, if anything, an imperfectly transparent central bank would use its monetary policy procyclically. There have been moments between 2000 and 2002 when the ECB has appeared to do just that.

However, for simplicity, let us now assume that ε and η are distributed independently. In that case, the central bank will expect[17]

$$
\begin{aligned}
&E\left(L_{\mathrm{CB}}^{*}\right) \\
&\quad\approx \frac{1}{2}\left\{\frac{\left(\bar{\gamma}^{2}+\sigma_{\eta}^{2}\right)\left(1+\beta+\bar{\gamma}\right)^{2}+\left(\gamma_{1}+\beta^{2}\right)\left[\left(1+\beta+\bar{\gamma}\right)^{2}+\sigma_{\eta}^{2}\right]+\gamma_{1}(1+\beta)^{2}\sigma_{\eta}^{2}}{(1+\beta)^{2}\left[\left(1+\beta+\bar{\gamma}\right)^{2}+\sigma_{\eta}^{2}\right]}\right\}k^{2} \\
&\quad+\frac{1}{2}\left\{\frac{\left(\bar{\gamma}^{2}+\sigma_{\eta}^{2}\right)\left(1+\beta+\bar{\gamma}\right)^{2}+\left(\gamma_{1}+\beta^{2}\right)\left[\left(1+\beta+\bar{\gamma}\right)^{2}+\sigma_{\eta}^{2}\right]+\gamma_{1}(1+\beta)^{2}\sigma_{\eta}^{2}}{(1+\beta+\bar{\gamma})^{2}\left[\left(1+\beta+\bar{\gamma}\right)^{2}+\sigma_{\eta}^{2}\right]}\right\}\sigma_{\varepsilon}^{2}
\end{aligned}
\tag{3.9}
$$

Notice that, in (3.9), $\bar{\gamma}$ and σ_{η} appear in matched pairs of the same order in each term. This makes conservatism in monetary policy (credibility) and a lack of transparency into strategic substitutes, as far as the bank is concerned. That would explain Issing's (1999) comments about central bank policy, in that the bank will only have an interest in creating a lack of transparency, and in misrepresenting its preferences as being more conservative than they really are, if

$$
\begin{aligned}
&E\left(L_{\mathrm{CB}}^{*}\right)-E\left[L_{\mathrm{CB}}^{*}(\gamma_{1})\right] \\
&\quad\approx \frac{1}{2}\left\{\frac{\left(\bar{\gamma}^{2}+\sigma_{\eta}^{2}\right)\left(1+\beta+\bar{\gamma}\right)^{2}+\gamma_{1}(1+\beta)^{2}\sigma_{\eta}^{2}-\gamma_{1}^{2}\left[\left(1+\beta+\bar{\gamma}\right)^{2}+\sigma_{\eta}^{2}\right]}{(1+\beta)^{2}\left[\left(1+\beta+\bar{\gamma}\right)^{2}+\sigma_{\eta}^{2}\right]}\right\}k^{2} \\
&\quad+\frac{1}{2}\left\{\frac{\left(\bar{\gamma}^{2}+\sigma_{\eta}^{2}\right)\left(1+\beta+\bar{\gamma}\right)^{2}+\gamma_{1}(1+\beta)^{2}\sigma_{\eta}^{2}-\gamma_{1}^{2}\left[\left(1+\beta+\bar{\gamma}\right)^{2}+\sigma_{\eta}^{2}\right]}{(1+\beta+\bar{\gamma})^{2}\left[\left(1+\beta+\bar{\gamma}\right)^{2}+\sigma_{\eta}^{2}\right]}\right\}\sigma_{\varepsilon}^{2}<0
\end{aligned}
\tag{3.10}
$$

[17]Each loss function value quoted here and below depends on substituting the associated policy choices into the appropriate loss function: i.e. (3.7), (3.8) and y^{*} into (2.1) for (3.9); or (3.3a), (3.3b) and y_{PS}^{*} into (2.1) for (3.10). To evaluate $E\pi^{*2}$ and $E(y^{*}-k)^{2}$ we have to apply our assumption of the independence of ε and η in order to evaluate terms such as $E\eta^{2}\varepsilon^{2}$ or $E\eta^{2}\varepsilon$; *and* assume independence, *and* also first-order certainty equivalence, to obtain $E[\eta^{2}/(1+\beta+\gamma_{1})^{2}] \approx \sigma_{\eta}^{2}/[(1+\beta+\bar{\gamma})^{2}+\sigma_{\eta}^{2}]$ and $E[\gamma_{1}/(1+\beta+\gamma_{1})^{2}] \approx (\bar{\gamma}^{2}+\sigma_{\eta}^{2})/[(1+\beta+\bar{\gamma})^{2}+\sigma_{\eta}^{2}]$.

where $L^*_{CB}(\gamma_1)$ denotes the central bank's welfare had it announced its chosen preferences *ex ante*. This expression is negative if

$$\left(\overline{\gamma}^2 + \sigma_\eta^2\right)(1+\beta+\overline{\gamma})^2 + \gamma_1(1+\beta)^2\sigma_\eta^2 < \gamma_1^2\left[(1+\beta+\overline{\gamma})^2 + \sigma_\eta^2\right] \qquad (3.11)$$

Hence the desire to use or maintain a lack of transparency vanishes as $\sigma_\eta^2 \to 0$ since then $\gamma_1 \to \overline{\gamma}$. But an incentive to manipulate the private sector through a lack of transparency would still remain if σ_η^2 is not too large: (3.11) is satisfied by[18]

$$\sigma_\eta^2 < \frac{(2\overline{\gamma}+\eta)\eta(1+\beta+\overline{\gamma})^2}{(1+\beta+\overline{\gamma})^2 + \gamma_1\left[(1+\beta)^2 - \gamma_1\right]} \qquad (3.12)$$

This means the bank will always want to engineer a reputation of being more conservative *if* that does not create too much extra uncertainty at the same time. But (3.12) implies it is only possible to do that if η is strictly positive. In other words, there is a tradeoff between the scope for manipulating information strategically and the extra degree of uncertainty created. But the bank could always arrange to reveal just enough information to ensure (3.12) was satisfied. Moreover the right-hand side of (3.12) is increasing in positive values of η, at least as long as the bank wishes to remain more conservative than the government ($\gamma_1 \leq \beta$), or if the private sector believes the bank itself to be conservative ($\overline{\gamma} \leq 1$). These two conditions imply an increasing upper bound on the permitted values of σ_η^2, as does an increasingly conservative government (lower values of β). Under those circumstances, the incentive to manipulate through imperfect transparency increases.[19]

3.4 The Bank's Conjectures: the No 'Malice Aforethought' Solution

Our model of imperfect transparency assumes that the central bank pursues the conventional Nash equilibrium set up at the start, despite having access to private information. We do not consider what would happen if the bank were to go back and re-optimize its decisions, taking into account what it

[18]We have assumed that the denominator of (3.12) is positive: $\eta \leq 1+\beta$ would be sufficient, which implies the private sector assumes that, irrespective of the value of γ_1 finally chosen, the central bank will remain more conservative than the government.

[19]Our strategic reputation result also appears in Sibert's (2002) dynamic analysis, which shows that the private sector would expect less inflation if there were *no* private information problems—and increasingly so, the more inflation averse the policymakers' preferences were for future periods. This is the result we have in this section. But the strategic reputation effect may be exploited less in the first period, when the bank's reputation is at its most vulnerable. As a result inflation, and the strategic reputation effect, are more affected by the length of time left in office than by current or past performance. Nevertheless these are results from a model without fiscal policy or output stabilization. We conjecture that they generalize to our model, and can show that to be the case even when the private sector uses the correct expectations for π^e *and* the bank re-optimizes in the knowledge of what its lack of transparency will do to private sector decisions (the 'malice aforethought' solution of Appendix B).

now knows to be the disturbances which would be caused by its own lack of transparency, in (3.6), (3.7) and y^*. That is a perfectly valid alternative, but it produces a form of conjectural variations solution in which the bank exploits the fact that it can use its access to private information as a form of leadership which forces the private sector/fiscal authority off its optimal reaction function. That would help the bank, but not the private sector or fiscal authority. It implies a one-sided variation around the Nash solution, the opportunity for which arises only when the bank *actively* and consciously pursues the consequences of its lack of transparency. This is the solution we discuss in Appendix B.

By contrast, we have the bank *passively* allowing imperfect transparency to have its effect here. Although this may make the bank worse off than under a more active strategy, society as a whole will be better off. This, we argue, is closer to Issing's (1999) perception that the purpose of a lack of transparency is to separate 'the need to know' from 'the need to understand'—without injecting any incentive to confuse or for the public 'not to know' at the same time.

Our solution therefore contains no 'malice aforethought'. Nevertheless the key point is that, even with this less self-interested solution, the bank will still find that it has an incentive to create and exploit a strategic reputation for its own ends. If the bank discovers that it can benefit from a strategic reputation in a restricted class of 'optimal' decisions, then it will still want to exploit that reputation in any solution that allows for further re-optimizations—since any new solution must at least reach the performance of the old. In other words, our solution is sufficient to identify the incentive for a strategic reputation among more liberal central banks who opt for less than full transparency.

4 Imperfect Transparency over Policy Goals

4.1 Measurable Information versus Inferred Information

We now compare our preference transparency results with the 'control errors' approach of Faust and Svensson (2001), Cukierman (2000), Jensen (2002) and Geraats (2002), in which the question of transparency is restricted to the measurable elements in the private sector's information set. That information set includes the exogenous conditioning information, any decisions made by other players outside the game, and the desired values for the target variables of any player modelled within the game. It does not include any endogenous variables from the same period since such variables could not be part of any player's conditioning information. And it does not include any information which is not directly observable but which has to be inferred from observations on those endogenous variables. Typically that covers the model parameters and the preference parameters which have been used by the associated

decision-makers. In other words we are making a distinction between what is measurable, publicly or privately, through conventional data-gathering techniques and what can be obtained only by inference or deduction from observed behaviour, i.e. upon additional assumptions about economic behaviour, optimization, risk aversion or the underlying probability models. The only exception to this classification might be the intended values for the target variables, which might have to be inferred.[20] But that does not matter as we shall see.

4.2 The 'Control Errors' Approach

The conventional analysis of this kind of transparency problem has the central bank in office for a notional two-period interval, but allows no fiscal policy or wage-setting decisions. This forces the bank to consider its policies over a two-period horizon, but implies that the bank will retain the right to release further information/data about its intentions and conditioning information at the end of the first period. This, according to Padoa-Schioppa (2000), is exactly how the ECB operates and is intended to operate. Thus, the bank now has a two-period loss function like (2.1):[21]

$$L_{\mathrm{CB}} = \tfrac{1}{2}\left[\pi_t^2 + \tau_t^2 + \gamma(y - k_{\mathrm{CB}})^2\right] \tag{4.1}$$

in which k_{CB} contains the bank's output target and 'preferred' conditioning information. But, as in Section 3, output responses depend on the markets' expectations for inflation. And π_t^{e} is defined to be $E(\pi_{t+1}|I_t)$—the inflation rate which is expected to hold at the end of period t and into period $t + 1$, i.e. after the decisions of period t have been taken and implemented. It is therefore conditional on the private sector's information at the start of period t. However, as π will be chosen as a function of k_{CB} and hence depends on the bank's information set, it is obvious that an outsider will be unable to distinguish between random shocks to output and mistakes made in the values assumed for k_{CB}. Hence there is a role for transparency here. The bank could reveal the true value of k_{CB}, e.g. by publishing its inflation forecasts (Geraats, 2002), or it could decide not to do so. And given those forecasts and the assumptions which underlie them, the private sector could deduce the value

[20]Recall that any decision problem under uncertainty can be split into four components: the objective (preferences and aspirations), the model (the feasible constraints), the measure of risk aversion and the (external) conditioning information: Hughes Hallett and Rees (1983). All we have done here is put aspirations (target values) into the 'observable' information set, leaving the preferences (relative priorities), the model and risk aversion measure in the 'inferred' information set.

[21]For comparability, Geraats also has a linear term for $y_t - k_{\mathrm{CB}}$ which implies an adjustment to k_{CB} in (4.1), and (without loss of generality) we have rescaled the output measure in order to remove the scale parameter in Jensen's inflation equation. Geraats also has the uncertain target value on inflation rather than output, but that is just an alternative normalization for the purposes of our analysis (Jensen, 2002).

of k_{CB} from (2.6) as long as there is no preference uncertainty at the same time.

4.3 Would the Central Bank Find this Lack of Transparency Useful?

If we take the preference parameters to be known, we have the following loss functions:

$$L_{CB} = \tfrac{1}{2}\left[\pi^2 + \tau^2 + \gamma(y - k_{CB})^2\right] \qquad \text{where } \gamma < \beta \tag{4.2}$$

for the central bank and

$$L_{FA} = \tfrac{1}{2}\left[\pi^2 + \tau^2 + \beta(y - k_{FA})^2\right] \tag{4.3}$$

for the government. We suppose the bank's conditioning information and implicit target values to be uncertain:

$$k_{CB} = k_{FA} + v \tag{4.4}$$

where k_{FA} is the private sector's estimate (known also to the bank) and v is a random variable with mean zero and variance σ_v^2. Information on k_{CB} remains the bank's private property.

The private sector and the fiscal authorities will now have to use k_{FA} as their best estimate of k_{CB} when computing their versions of π^e and π^*. Likewise the central bank must assume the fiscal authorities will use k_{FA} when computing its estimate of the fiscal authorities' reaction function for τ, and that π^e refers to private sector expectations throughout. Hence we will get inflation from (2.3) with $k = k_{CB}$, and the fiscal balance from (2.5) with $k = k_{FA}$, where it is understood that $\pi^e = \gamma k_{FA}/(1 + \beta)$ and that the fiscal authorities have to use their own estimate of $\pi = f(k_{FA})$ to solve (2.3) and (2.5). This leads to

$$\pi^* = \frac{\gamma}{1+\beta} k_{FA} - \frac{\gamma[\varepsilon - (1+\beta)v]}{1+\beta+\gamma} \tag{4.5}$$

$$\tau^* = \frac{-\beta}{1+\beta} k_{FA} + \frac{\beta\varepsilon}{1+\beta+\gamma} \tag{4.6}$$

and

$$y^* = \frac{\beta}{1+\beta} k_{FA} + \frac{\varepsilon + (1+\beta)\gamma v}{1+\beta+\gamma} \tag{4.7}$$

Since the central bank knows its choice of v, this means

$$\pi^e - \pi^e_{FA} = \frac{\gamma v}{1+\beta} \qquad \pi^* - \pi^*_{FA} = \frac{\gamma(1+\beta)v}{1+\beta+\gamma} \qquad \tau^* - \tau^*_{FA} = 0$$

Hence the central bank might be tempted to manipulate its choice of inflation target by choosing $v < 0$ (i.e. by choosing a lower inflation target, $k_{CB} < k_{FA}$). But that will not affect either the decisions of the fiscal authori-

ties (τ^*) *or* private sector beliefs (π^e_{FA}). In this case, inserting (4.5)–(4.7) into (4.3) yields

$$E\left(L^*_{FA}\right) = \theta_1 k^2_{FA} + \theta_2\sigma^2_\varepsilon + \theta_3\sigma^2_v + \theta_4\rho\sigma_\varepsilon\sigma_v \tag{4.8}$$

where

$$\theta_1 = \frac{\gamma^2+\beta^2+\beta}{2(1+\beta)^2} > 0 \qquad \theta_2 = \frac{\gamma^2+\beta^2+\beta}{2(1+\beta+\gamma)^2} > 0$$

and

$$\theta_3 = \frac{\gamma^2(1+\beta)^2(1+\gamma)}{2(1+\beta+\gamma)^2} > 0 \qquad \theta_4 = \frac{\gamma(1+\beta)(\beta-\gamma)}{(1+\beta+\gamma)^2} \geq 0$$

where $\text{cov}(\varepsilon, v) = \rho\sigma_\varepsilon\sigma_v$, ρ is the correlation coefficient and $\gamma \leq \beta$.

Equation (4.8) shows that a lack of goal transparency does indeed harm social welfare since $\theta_3 > 0$. But the more the bank's policies turn out to be countercyclical ($\rho < 0$), the less this matters. Policy activism may therefore help to offset imperfect transparency. Moreover $\partial\theta_3/\partial\gamma > 0$ for all $\gamma \leq 1$. This implies that goal transparency and credibility are strategic complements; or, equivalently, that a lack of transparency and credibility are substitutes (as might have been inferred from Issing's (1999) discussion). But once again, the more conservative the central bank, the less important is this issue of goal transparency.

Thus a central bank which is able to achieve credibility by single-mindedly controlling inflation has little need to worry about economic transparency or the need to provide it. That reflects the ECB's attitude very well. Moreover, *any* central bank will be less concerned about transparency than the private sector since

$$E\left(L^*_{CB}\right) = \phi_1 k^2_{FA} + \phi_2\sigma^2_\varepsilon + \phi_3\sigma^2_v + \phi_4\rho\sigma_\varepsilon\sigma_v \tag{4.9}$$

where

$$\phi_1 = \frac{\gamma^2+\beta^2+\gamma}{2(1+\beta)^2} > 0 \qquad \phi_2 = \frac{\gamma^2+\beta^2+\gamma}{2(1+\beta+\gamma)^2} > 0$$

and

$$\phi_3 = \frac{\gamma^2(1+\beta)^2+[\beta(\gamma-1)-1]^2}{2(1+\beta+\gamma)^2} > 0 \qquad \phi_4 = \frac{\beta\gamma-(\beta+1)(1+\gamma^2)}{(1+\beta+\gamma)^2} < 0$$

where $\phi_3 < \theta_3$. And it will favour procyclical policies, rather than the countercyclical targets preferred by the private sector, since $\phi_4 < 0$ but $\theta_4 \geq 0$.

4.4 Political Economy Implications

Figures 1 and 2 show some consequences of these results. Figure 1 shows the private sector welfare losses, with and without full economic transparency,

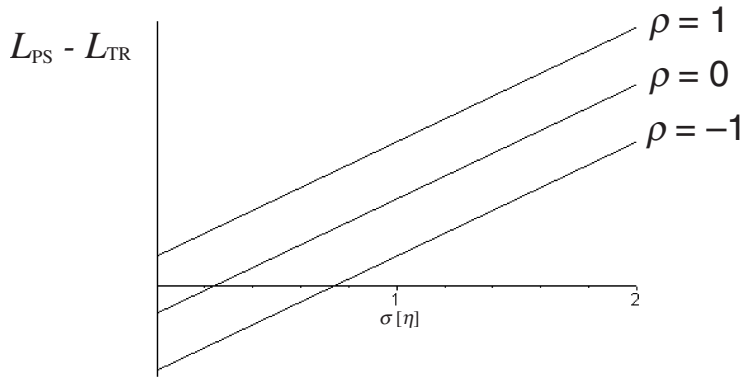

FIG. 1 Difference Between the Private Sector Objective Function Without and With Transparency, for Different Correlation Coefficients: $L_{PS} = \theta_1 k_{FA}^2 + \theta_2 \sigma_\varepsilon^2 + \theta_3 \sigma_v^2 + 2\theta_4 \rho_{\varepsilon\eta}$, no transparency; $L_{TR} = \theta_1 k_{FA}^2 + \theta_2 \sigma_\varepsilon^2$, full transparency; $\beta = \lambda = 1$, $\gamma = 0.5$, $k_{FA} = 1$, $\sigma_\varepsilon = 1$

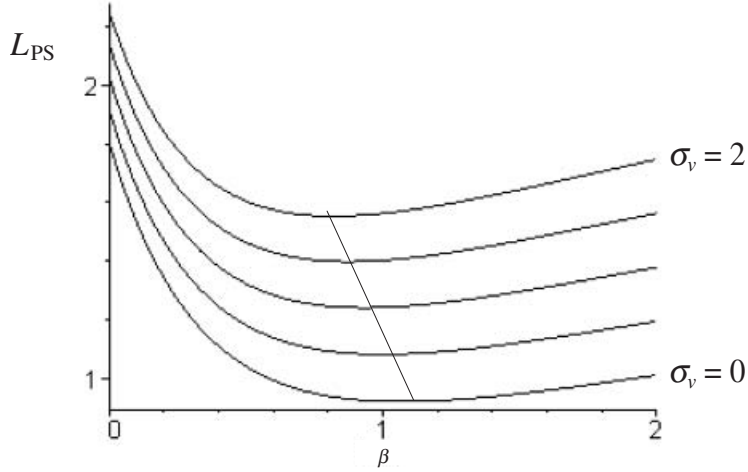

FIG. 2 $\gamma = 0.5$, $\lambda = 1$, $k_{FA} = 1$, $\rho = 0$, $\sigma_\varepsilon = 1$

for some plausible values of the parameters in our problem. Imperfect transparency clearly causes losses to the private sector if $\rho \geq 0$, i.e. if monetary policy becomes more procyclical. But it may improve the situation if $\rho \leq 0$ and σ_ε is not too large.

Figure 2 meanwhile shows the private sector's welfare function for different levels of fiscal activism (β). An increasing lack of transparency clearly makes the private sector want governments to become more cautious about fiscal policy—simply because it cannot be sure how the central bank would react with its monetary policy if fiscal policy were to be used more vigorously.

The significance of these two diagrams is that the lower the value of σ_v^2 (the more goal transparency), the better the outcomes for the private sector. But (4.9) shows that smaller values of σ_v^2 also lead to smaller values of $E(L_{CB}^*)$ unless $\rho > -\phi_3\sigma_v/\phi_4\sigma_\varepsilon > 0$. Hence, except in the case of very procyclical policies ($\rho > 0$) in a world of large output shocks (σ_ε large),[22] the central bank will have no incentive to try to manipulate the outcomes through imperfect (goal) transparency.

5 Conclusions

As it offers no strategic opportunities to the central bank, except as a substitute for credibility which may be difficult to acquire by other means, imperfect economic transparency is really an exercise in controlling the use of private information. It does not allow the bank to make better decisions. Hence the more conservative the central bank, the less it will feel the need to provide full transparency in this sense. However, that may be less apparent to a private sector that needs information pooling in order to make better decisions. Hence the suspicion that the central bank is being too conservative, or too favourable to procyclical policies, may remain.

Political transparency is quite different. Here the bank has a clear strategic interest in restricting transparency. But the private sector would clearly benefit from greater transparency in this sense, since it could then make better (as well as better informed) decisions. Political transparency therefore allows us to understand *how* decisions are made, as well as what information goes into them. It is important to maintain a distinction between these two forms of transparency since creative economic transparency alone would provide no protection against the bank's incentive to establish a strategic reputation in order to manipulate private sector expectations.

Appendix A: The Error in the First-order Approximation in (3.6)

To evaluate this error, we have to evaluate the expectation terms in (3.6):

$$E\left(\frac{\gamma_1}{1+\gamma_1+\beta}\right) \approx \frac{\bar{\gamma}}{1+\beta+\bar{\gamma}} - \frac{\operatorname{cov}(\gamma_1, 1+\gamma_1+\beta)}{(1+\beta+\bar{\gamma})^2} + \frac{\bar{\gamma}\operatorname{var}(1+\gamma_1+\beta)}{(1+\beta+\bar{\gamma})^3} \tag{A1}$$

where $\bar{\gamma} = E(\gamma_1)$ and β is fixed and known to the government and private sector. But $\operatorname{var}(1 + \gamma_1 + \beta) = \sigma_\eta^2$ and $\operatorname{cov}(\gamma_1, 1 + \gamma_1 + \beta) = \sigma_\eta^2$. Hence

$$\pi^e \approx \theta\frac{\bar{\gamma}k}{1+\beta}$$

[22]Note $\rho > 0$ implies $\sigma_v \neq 0$. And that $\phi_3/\phi_4 < 0$ holds for all β, $\gamma > 0$.

where

$$\theta = \frac{\bar{\gamma}(1+\beta+\bar{\gamma})^2 - \sigma_\eta^2(1+\beta)}{\bar{\gamma}\left[(1+\beta+\bar{\gamma})^2 + \sigma_\eta^2\right]} \leq 1$$

follows from the left-hand side of (3.6). The 'true' expectation is therefore proportional to our first-order equivalent approximation, with the factor of proportionality being less than unity but approaching unity as $\sigma_\eta^2 \to 0$. In fact

$$1-\theta = \frac{\sigma_\eta^2(1+\bar{\gamma}+\beta)}{\bar{\gamma}\left[(1+\beta+\bar{\gamma})^2 + \sigma_\eta^2\right]} \tag{A2}$$

so that (a) $\theta \to 1$ monotonically as $\sigma_\eta^2 \to 0$; (b) $\theta \to 1$ as $\bar{\gamma}$ increases; and (c) $\theta \to 1$ as β increases. Conversely $1 - \theta$ *increases* as $\bar{\gamma} \to 0$ or $\beta \to 0$. Consequently the more conservative the central bank and/or the more conservative the fiscal authorities, the larger is the error in the first-order approximation and the lower the 'true' expectations for inflation should be. But, as we show next, the policy authorities would really have to be extremely conservative for those errors to be of any significant size. For all reasonable values of β and $\bar{\gamma}$, including some fairly conservative values, the expectations error would be less than 10 per cent.

(a) Suppose γ_1 is distributed uniformly on the unit interval, implying that the central bank is always conservative with respect to inflation control. Then $\bar{\gamma} = 1/2$ and $\sigma_\eta^2 = 1/12$. Equation (A2) now implies that the error in π^e would be less than 10 per cent if $(1/6)(1.5 + \beta)/[(1.5 + \beta)^2 + 1/12] < 0.1$; i.e. if $\beta \geq 0.117$. In other words, we could be 100 per cent sure that the error in π^e would be less than 10 per cent if β was at least greater than a value four times smaller than the central bank's preference for output stabilization. That seems inevitable. It would take an outrageously conservative government, relative to the central bank, to produce errors larger than this.

(b) Suppose γ_1 is distributed uniformly on the interval (0, 0.9). Then $\bar{\gamma} = 0.45$, $\sigma_\eta^2 = 0.061$ and the expectations errors will be less than 10 per cent for *any* value of $\beta \geq 0$.

(c) Suppose γ_1 is distributed normally such that 99 per cent of the distribution (±3SD) lies within the unit interval. Then we are 99 per cent certain the error in π^e will be less than 10 per cent if

$$\frac{\bar{\gamma}(1+\beta+\bar{\gamma})}{9} \Big/ \left[\frac{(1+\beta+\bar{\gamma})+\bar{\gamma}^2}{9}\right] < 0.1$$

i.e. if $\gamma \geq 0.1$, given *any* value of $\beta > 0.01$. Or if $\beta \geq 0.1$, given any value of $\bar{\gamma} > 0.01$. Again, it seems almost certain that these inequalities would be satisfied.

Appendix B: The Incentive to Use Imperfectly Transparent Strategies when the Bank Optimizes with Malice Aforethought

We examine the outcomes, and the incentive for the bank to use its imperfect transparency strategically by strategically misrepresenting its preferences with $\eta > 0$, when

the bank re-optimizes its monetary policy conditional on the private sector's response to the bank's access to private information (imperfect transparency). This is the 'malice aforethought' solution which was avoided in Section 3.4. We will also assume that the private sector would (eventually) learn to use the corrected inflationary expectations: $\pi^e = \bar{\gamma}\bar{k}/(1+\beta)$ from Appendix A, where $\bar{k} = \theta k$.

The bank's re-optimization, (2.3) with π^e above and (3.8), yields

$$\pi^* = \frac{\gamma_1}{1+\gamma_1}\left(\frac{1+\bar{\gamma}}{1+\beta}\right)\bar{k} - \frac{\gamma_1(1+\bar{\gamma})\varepsilon}{1+\gamma_1(1+\beta+\bar{\gamma})} \tag{B1}$$

and

$$E(\pi^*) \approx \frac{\bar{k}}{1+\beta}\left[\bar{\gamma} - \frac{\sigma_\eta^2}{(1+\bar{\gamma})^2}\right]$$

Hence $E(\pi^*) < \pi^e$ in this case too, since $\sigma_\eta^2 \neq 0$ by assumption. Now evaluating L_{CB}, we get

$$L_{CB} = \frac{\bar{k}^2}{(1+\beta)^2}\left\{\frac{(\bar{\gamma}+\eta)^2(1+\bar{\gamma})^2}{(1+\bar{\gamma}+\eta)^2} + \beta^2 + \frac{\gamma_1[(1+\beta)-1]}{(1+\bar{\gamma}+\eta)^2}\right\} \tag{B2}$$

plus other terms not involving η or σ_η^2. Hence, using $\gamma_1 = \bar{\gamma} + \eta$,

$$\frac{\partial L_{CB}}{\partial \eta} = \frac{2\gamma_1\left\{(1+\bar{\gamma})^2 + [(1+\beta)\eta - 1][(1+\beta)(1+\bar{\gamma})+1]\right\}}{(1+\bar{\gamma}+\eta)^3} \tag{B3}$$

Since the first term in braces is positive, we need to choose $\eta < 1/(1+\beta)$ to make the second term negative and hence have a chance of reducing/minimizing L_{CB} in this re-optimization exercise. In fact the optimal choice in this case would be

$$\eta^* = \frac{(1+\bar{\gamma})(\beta-\bar{\gamma})+1}{(1+\beta)^2(1+\bar{\gamma})+(1+\beta)} \tag{B4}$$

which is positive as long as $\beta \geq \bar{\gamma} - 1/(1+\bar{\gamma})$, and is never too negative ($\eta > -\bar{\gamma}$). Consequently, there is *always* an optimal choice of η, and hence always an incentive to exploit imperfect transparency by creating a strategic reputation even in this case of malice aforethought and corrected inflationary expectations. The manipulation of information on preferences is the way to do that, and in all reasonable cases (i.e. $\beta \geq \bar{\gamma}$) it requires the bank to represent itself as being more conservative than it really is ($\bar{\gamma} < \gamma_1$ or $\eta > 0$). The conclusions of Section 3 therefore go through unchanged.

References

Alesina, A. and Gatti, R. (1995). 'Independent Central Banks: Low Inflation at No Cost', *American Economic Review*, Vol. 85, pp. 196–200.

Balke, N. and Haslag, J. (1992). 'A Theory of Fed Watching in a Macroeconomic Policy Game', *International Economic Review*, Vol. 33, pp. 619–628.

Barro, R. and Gordon, D. (1983). 'A Positive Theory of Monetary Policy in a Natural Rate Model', *Journal of Political Economy*, Vol. 91, No. 4, pp. 589–610.

Beetsma, R. and Jensen, H. (1998). 'Inflation Targets and Contracts with Uncertain Central Banker Preferences', *Journal of Money, Credit and Banking*, Vol. 30, pp. 384–403.

Blinder, A. (1997). 'What Central Bankers Can Learn from Academics—and Vice Versa', *Journal of Economic Perspectives*, Vol. 11, pp. 3–19.

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

Bomfin, A. and Reinhart, V. (2000). *Making News: Financial Market Effects of Federal Reserve Disclosure Practices*, Washington, DC, Board of Governors, Federal Reserve.

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

Canzoneri, M., Cumby, R. and Diba, B. (2001). 'Is the Price Level Determined by the Needs of Fiscal Solvency?', *American Economic Review*, Vol. 91, pp. 1221–1238.

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

Cukierman, A. (2000). 'Accountability, Credibility, Transparency and Stabilisation Policy in the Euro System', *Working Paper*, Tel Aviv University.

Cukierman, A. and Meltzer, A. (1986). 'A Theory of Ambiguity Credibility and Inflation under Discretion and Asymmetric Information, *Econometrica*, Vol. 54, pp. 1099–1128.

Debelle, G. and Fischer, S. (1994). 'How Independent Should the Central Bank be?', in J. C. Fuhrer (ed.), *Goals, Guidelines and Constraints Facing Monetary Policy Makers*, Boston, MA, Federal Reserve Bank of Boston.

Demertzis, M., Hughes Hallett, A. and Viegi, N. (1999). 'An Independent Central Bank Faced with Elected Governments', *Discussion Paper 2219*, Centre for Economic Policy Research, London; forthcoming in *European Journal of Political Economy*.

Eijffinger, S. and Geraats, P. (2002). 'How Transparent Are Central Banks?', *Discussion Paper 3188*, Centre for Economic Policy Research, London.

Eijffinger, S., Hoebrichts, M. and de Haan, J. (2000), 'A Theory of Central Bank Accountability', *Discussion Paper 2354*, Centre for Economic Policy Research, London.

Fagin, R., Halpern, J., Moses, Y. and Yardi, M. (1995). *Reasoning about Knowledge*, Cambridge, MA, MIT Press.

Faust, J. and Svensson, L. (2001). 'Transparency and Credibility: Monetary Policy with Unobservable Goals', *International Economic Review*, Vol. 42, pp. 369–407.

Friedman, B. (1997). 'The Rise and Fall of Monetary Targets for US Monetary Policy', in I. Kiroda (ed.), *Towards a More Effective Monetary Policy*, New York, St Martin's Press.

Geraats, P. (2002). 'Central Bank Transparency', *Economic Journal*, Vol. 112, pp. F532–F565.

de Haan, J. and Eijffinger, S. (2000). 'The Democratic Accountability of the European Central Bank', *Journal of Common Market Studies*, Vol. 38, pp. 393–408.

Hughes Hallett, A. and Rees, H. J. B. (1983). *Quantitative Economic Policies and Interactive Planning*, Cambridge, Cambridge University Press.

Issing, O. (1999). 'The Eurosystem: Transparent and Accountable', *Journal of Common Market Studies*, Vol. 37, pp. 503–520.

Jensen, H. (2002). 'Optimal Degrees of Transparency in Monetary Policymaking', *Scandinavian Journal of Economics*, Vol. 104, No. 3, pp. 399–422.

King, M. (1997). 'Changes in UK Monetary Policy Rules: Rules and Discretion in Practice', *Journal of Monetary Economics*, Vol. 39, pp. 81–87.
Kuttner, K. and Posen, A. (1999). 'Does Talk Matter After All? Inflation Targeting and Central Bank Behaviour', *Report 88*, Federal Reserve Bank of New York.
Kuttner, K. and Posen, A. (2000). 'Inflation, Monetary Transparency, and G3 Exchange Rate Volatility', *Report 00-6*, Institute for International Economics, Washington, DC.
McCallum, B. T. (1997). 'Critical Issues Concerning Central Bank Independence', *Journal of Monetary Economics*, Vol. 39, pp. 99–112.
Muscatelli, A. (1998). 'Optimal Inflation Contracts and Inflation Targets with Uncertain Central Bank Preferences: Accountability through Independence?', *Economic Journal*, Vol. 108, pp. 529–542.
Nolan, C. and Schaling, E. (1998). 'Monetary Policy Uncertainty and Central Bank Accountability', *De Economist*, Vol. 146, pp. 585–602.
Nordhaus, W. (1994). 'Policy Games: Coordination and Independence in Monetary and Fiscal Policies', *Brookings Papers on Economic Activity*, Vol. 25, No 2, pp. 139–216.
Padoa-Schioppa, T. (2000). 'An Institutional Glossary of the Eurosystem', in *The European Central Bank: Independence and Accountability*, *ZEI Policy Paper B16*, University of Bonn.
Persson, T. and Tabellini, G. (1990). *Macroeconomic Policy, Credibility and Politics*, Amsterdam, Harwood Academic.
Roberts, J. M. (1995). 'New Keynesian Economics and the Phillips Curve', *Journal of Money, Credit and Banking*, Vol. 27, pp. 975–984.
Rogoff, K. (1985). 'The Optimal Degree of Commitment to a Monetary Target', *Quarterly Journal of Economics*, Vol. 100, No. 4, pp. 1169–1190.
Rotemberg, J. and Woodford, M. (1998). 'An Optimisation Based Econometric Framework for the Evaluation of Monetary Policy', *NBER Technical Working Paper 233*, NBER.
Sheffrin, S. (1989). *The Making of Economic Policy*, Oxford, Blackwell.
Sibert, A. (2002). 'Monetary Policy with Uncertain Central Bank Preferences', *European Economic Review*, Vol. 46, pp. 1093–1110.
Svensson, L. and Faust, J. (2002). 'The Equilibrium Degree of Transparency and Control in Monetary Policy', *Journal of Money, Credit and Banking*, Vol. 34, pp. 520–539.
Theil, H. (1964). 'Optimal Decision Rules for Government and Industry', Amsterdam, North-Holland.
Walsh, C. E. (2002). 'Accountability, Transparency and Inflation Targeting', *Journal of Money, Credit and Banking*, forthcoming.