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ABSTRACT

Three Models of Imperfect Transparency in Monetary Policy*

We present three different models of imperfect transparency in monetary policy: political transparency, economic transparency and constructive ambiguity. The first two show that transparency reduces the variability of inflation and the output gap but does not affect their average levels. But if the Central Bank is unable to commit to one particular set of preferences for all circumstances, in line with the hypothesis of constructive ambiguity, we find that both the levels and the variability of output and inflation may be affected. An empirical examination of these predictions, based on an index recently constructed by Eijffinger and Geraats, shows that macroeconomic averages are not much affected by transparency. But transparency appears to reduce the variability of inflation while increasing the variability of output. That suggests that Central Banks may have been exploiting constructive ambiguity more than a lack of transparency.

JEL Classification: E52 and E58
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1 Introduction

Many economists agree that greater transparency in monetary policy is desirable because it allows the private sector to make better - that is, welfare improving - decisions, as well as better informed decisions (Blinder, 1998). But not all economists agree.

Some argue that incomplete transparency is optimal, as the effect on the Central Bank's reputation and its consequent ability to control inflation has to be balanced against the private sector's wish to see output, employment and prices stabilised (Faust and Svensson, 2001 or Jensen, 2002). Others argue that certain restrictions on transparency are important for operational reasons. Once again the idea is to reinforce the Bank's credibility (see Eijffinger and Hoeberichts, 2002) or to separate 'the need to know' from 'the need to understand' (Issing, 1999). These views reveal a conflict which economic theory has yet to resolve. The purpose of this paper is to examine different models of imperfect transparency in order to identify the circumstances in which incomplete transparency might indeed be optimal, and the circumstances in which it might not.

In practice, many Central Banks have actually increased their transparency in recent years - using inflation forecasts, explanations of the reasoning behind their decisions, and sometimes voting records on policy decisions or a discussion of the 'bias' in those decisions, to do so. Yet, on the basis of the reasoning currently available, one cannot tell whether greater transparency has actually made any difference to the impact and effectiveness of the chosen policies. Nor is it possible to determine exactly what kinds of impacts one should expect, in terms of inflation or output stability. Our purpose therefore is to examine what effects a lack of Central Bank transparency should be expected to have on monetary policies and their outcomes.

Kuttner and Posen(2000) list a number of characteristics thought 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 as well as the way in which that information has been used. This distinction relates directly to the potential for 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), for example, argue that it enhances the Central Bank's ability to use discretionary policies, while Faust and Svensson

(2002) argue the opposite. In fact, both sets of authors agree that transparency will reduce the noise and the imprecision in the private sector's decision making. They only differ as to whether greater transparency increases the ability of the Central Bank and private sector to make consistent decisions, or whether it reduces the Central Bank's ability to control the private sector's natural tendency to avoid monetary discipline.

The matter is further complicated by the fact that a lack of transparency may arise for a variety of different reasons. It could arise when the Central Bank has private information about the nature of shocks and the way in which policy affects the economy (Cukierman, 1992, 2000); or when the Central Bank has not stated its objectives clearly, deliberately or otherwise (Cukierman and Meltzer 1986); or when the public is uncertain about the preferences of the Central Bank (Nolan and Schaling, 1998, Muscatelli, 1998); or when the Bank is uncertain how much attention it wants to pay to some of its targets in difficult or risky circumstances (Sims, 2003, Kasa, 2002). To allow for each of these possibilities, we need to present imperfect transparency in two forms: imperfect transparency about priorities; and imperfect transparency about objectives, conditioning information, implementation errors or shocks. In either case, a lack of transparency introduces a disturbance which distorts the private sector' expectations for inflation. That provides an incentive for the Central Bank to use its private information strategically; and equally for the private sector to demand greater accountability.

In this paper we examine these issues using a theoretical model of monetary policy stripped down to its key components. We distinguish between a lack of transparency (political and economic) which the private sector can nevertheless internalise when forming its expectations, and a presence of ambiguity in the operations of a Central Bank, which the private sector cannot internalise in full. We find that a lack of transparency does not alter the average inflation or output performance of an economy. But it does affect the stability of the economy, increasing both inflation variability and output variability. By contrast, ambiguity affects inflation and output levels (by depressing them), while having an ambiguous effect on output stability. That means output instability could either rise with increasing clarity of intentions, or fall. Consequently, we use a recently constructed index of Central Bank transparency to determine exactly what effects imperfect transparency has actually had in the main OECD economies[2].

The paper is organised as follows: Section two defines political, economic and constructive ambiguity forms of incomplete transparency, and identifies the way in which they affect the moments of the inflation and output gap distributions. Section three provides the comparison between these results and the possible motives for incomplete transparency. Section four then employs the index of transparency by Eijffinger and Geraats (2002) to test the empirical relevance of

[2] See Eijffinger and Geraats (2002). The empirical part of this exercise is the counterpart to the analysis undertaken by Alesina and Summers (1993), in which they explored how (indices of) independence affected macroeconomic performance.

our results. We look at two alternative groupings of this index and discuss the sensitivity of our results. Section five concludes.

2 Three Models of Transparency

We adopt a conservative central banker model, in which the Central Bank (CB) has the following objective function[3]:

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

constrained by a simple Lucas supply function:

$$y = \pi - \pi^e + \varepsilon \tag{2}$$

where y and π are measured as deviations from their steady state paths[4]. The model produces the following solutions for the policy variables in question:

$$\begin{aligned} \pi &= bk - \frac{b}{1+b}\varepsilon \\ \pi^e &= bk \\ y &= \frac{1}{1+b}\varepsilon \end{aligned} \tag{3}$$

For simplicity, we assume that there is only one player in the game (i.e. a single monetary authority and no fiscal policy) and that there is no uncertainty in the transmission of policy effects. The presence of k is perhaps more controversial. The way k is defined in much of the literature is to note that some factors in the economy, such as income taxation or unemployment insurance, distort the labour-leisure decision and cause the market-determined level of employment (and output) to lie below their social optimum (Rogoff 1985). A value of $k > 0$ then reflects the policy maker's desire to correct this distortion. There have however, been objections as to whether having a central bank that sets out to impose an inflationary bias (i.e. $k \neq 0$) is a sensible specification to start with (Blinder 1997). We do not attempt to resolve that dispute here. Instead we simply note that k may be either positive or zero. Doubts about its exact value may constitute one source of transparency problems in monetary policy[5].

[3] This system in inflation and output gaps is based on the utility-based approach by Rotemberg and Woodford (1998) or Gali and Monacelli (2002).

[4] Lucas, (1972, 1973). But see extensions to this model in which fiscal policy and hence a second player (the fiscal authority or the government) is incorporated, appear in Hughes Hallett and Viegi (2003) or Geraats (2002).

[5] Note that uncertainty in parameter k also covers the case of uncertainty in the inflation target. It is easy to see that replacing π in (1) by $\pi - \hat{\pi}$ where $\hat{\pi} = E\hat{\pi} + u$ is the inflation target, $E\hat{\pi}$ is the private sector's expctation of that, and u is a random error, then the minimisation of (1) will be equivalent to having an inflation target which is known with certainty but an uncertain value of k with random component $v = (1+\gamma)^{1/2}u$. We treat that case in section 2.2.

In this paper we consider transparency problems which arise from three possible sources:

- misunderstandings, in the private sector, about the true value of the preference parameters b currently in use at the Central Bank;
- misperceptions about the value of k that the Central Bank can be expected to implement;
- uncertainty, within the Central Bank, about the most appropriate value of b to use when deriving their monetary policies.

We will identify the first of these with a lack of *political transparency;* the second with incomplete *economic transparency*; and the third with *constructive ambiguity (rational inattention,* or *a lack of consensus)* in policy making. We then examine how varying the degree of transparency, in any form, can affect the Central Bank's ability to achieve lower inflation and more stable output.

2.1 Imperfect Political Transparency

With political transparency we examine what happens when the public is uncertain about the true value of b. We define full transparency using a general specification in which the Central Bank attaches explicit weights to both its objectives:

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

Thus in identifying such a loss function, we determine the relative weight attached to the two objectives $\frac{b}{a}$, and the Marginal Rate of Substitution between them: $\frac{b}{a}\frac{\Delta\pi}{\Delta y}$. The issue of transparency arises when the public's perception about the bank's preferences, for example on output (β), differs from the values that the bank itself actually considers (b). We might define this discrepancy as

$$\beta = b + \eta$$

where η is a random error with $E(\eta) = 0$ and $V(\eta) = \sigma_\eta^2$. This implies that the public is correct on average, but may be mistaken when making guesses about the central bank preferences in individual cases or at certain points in time. But uncertainty about b implies that the relative importance that the Central Bank attaches to controlling inflation is also uncertain. That will affect inflation expectations and hence the Bank's best policies for controlling inflation. Since the relative weight on inflation, known to the Bank, is a constant, any uncertainty in b (as perceived by the public) will be matched by an equal and opposite uncertainty in a: i.e. $\alpha = a - \eta$, where $E(\alpha) = a$. Moreover, in this framework, decision rules can only be determined up to a factor of proportionality. Consequently, we will impose the normalisation $a = E(\alpha) = 1$[6]. However, full

[6] This is in fact the normalisation adopted in most studies of the transparency problem: see Cukierman (2000), Sibert (2002) or Muscatelli (1998).

transparency requires $E(\beta/\alpha) = b/a$, irrespective of any normalisation imposed. This will follow only if:

Definition 1*: Full political transparency occurs only if conditions* $E(\eta) = 0$ *and* $\sigma_\eta^2 = 0$, **both** *hold.*[7].

The private sector, nevertheless, expects the CB to implement:

$$\begin{aligned} \pi &= \beta k - \frac{\beta}{1+\beta}\varepsilon \qquad \text{with} \\ \pi^e &= \beta k \end{aligned}$$

Given this definition, and the public's perception, we now have:

Proposition 1 *If the CB can correctly anticipate what the public thinks, then an increase in political transparency reduces the variability of inflation and output but does not affect their average levels.*

Proof: The CB optimises the following:

$$\min_{\pi} L = \frac{1}{2} E\left[\pi^2 + b\left(\pi - \beta k + \varepsilon - k\right)^2\right] \tag{4}$$

leading to the following equilibrium inflation path:

$$\pi^* = \frac{b\left(1+\beta\right)k}{1+b} - \frac{b}{1+b}\varepsilon \tag{5}$$

Note that $E(\pi^*) = bk = E(\pi^e)$ because $E(\beta) = b$, so that the public's expectations are right on average. In that sense, this is still a rational expectations (RE) solution. Moreover, the variance of inflation is:

$$V(\pi^*) = E\left[\pi^* - E(\pi^*)\right]^2 = \left(\frac{b}{1+b}\right)^2 \left(k^2\sigma_\eta^2 + \sigma_\varepsilon^2\right) \tag{6}$$

assuming that $E(\eta, \varepsilon) = 0$. The variance of inflation is therefore, a function of the lack of transparency perceived by the public. Indeed as σ_η^2 increases (and transparency falls), then the variance of inflation increases as well:

$$\frac{\partial V(\pi^*)}{\partial \sigma_\eta^2} = \left(\frac{b}{1+b}\right)^2 k^2 > 0 \tag{7}$$

unless $b = 0$ or $k = 0$[8]. But the average level of inflation is **not** a function of the variance of η and therefore remains unaffected:

[7] $E(\eta) = 0$ alone is not sufficient. For proof see Demertzis and Hughes Hallett, 2002. However, the zero lower bound on the value of b (and a) means that their distributions are likely to be asymmetric and could not be exactly normal.

[8] The intution behind this result is that if $b = 0$ or $k = 0$, there is effectively only one target and one instrument and, as in Tinbergen's theory of economic policy, that target can be reached exactly on average. Consequently there is no issue of transparency to be analysed in this case - in contrast to the cases represented by (4), (5) and (6).

$$\frac{\partial E(\pi^*)}{\partial \sigma_\eta^2} = 0 \tag{8}$$

even if $b \neq 0$ or $k \neq 0$. We can likewise examine what happens to output. In equilibrium, output is equal to:

$$y^* = \frac{\varepsilon - \eta k}{1+b} \tag{9}$$

But this implies that $E(y^*) = 0$ and that

$$V(y^*) = \frac{\sigma_\varepsilon^2 + k^2 \sigma_\eta^2}{(1+b)^2} \tag{10}$$

if $E(\eta, \varepsilon) = 0$. Again this implies that the average level of equilibrium output remains unaffected by changes in the degree of transparency but the variance of output is reduced as political transparency increases:

$$\frac{\partial V(y^*)}{\partial \sigma_\eta^2} = \frac{k^2}{(1+b)^2} > 0 \tag{11}$$

2.2 Imperfect Economic Transparency

We consider next a different form of transparency, this time relating to the value of k which the CB targets[9], as perceived by the public. We identify this with imperfect economic transparency. Suppose the CB 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, $E(c) = k$. Then

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

This time the public will expect the CB to implement:

$$\begin{aligned} \pi &= bc - \frac{b}{1+b}\varepsilon \\ \pi^e &= bc \end{aligned}$$

Notice that k now contains all the conditioning information needed from outside the problem: on the exogenous and random variables, on decisions made by other players, and on the target values imposed by the policy makers themselves.

Proposition 2 *If there is uncertainty about the value of output the CB targets, then an increase in economic transparency reduces the variability of inflation and output. The levels of inflation and output remain, on average, unaffected.*

[9] This includes the control errors approach: Cukierman, 2000, Geraats, 2002, Faust-Svensson, 2001. In this section b is known to the public without uncertainty.

Proof: As the CB knows what the public's perceptions are, it will try to optimise the following loss function:

$$\min_{\pi} L = \frac{1}{2} E\left[\pi^2 + b\left(\pi - bc + \varepsilon - k\right)^2\right]$$

where $\pi^e = bc$. This results in an equilibrium level of inflation of

$$\pi^* = \frac{b\left(bc + k\right)}{1+b} - \frac{b}{1+b}\varepsilon$$

Since $E(c) = k$, this implies that $E(\pi^*) = bk$. Hence the private sector is again correct on average and the solution is a Rational Expectations equilibrium since $E(\pi^*) = E(\pi^e) = bk$. We can therefore write the variance of inflation as:

$$V(\pi^*) = E\left[\pi^* - E(\pi^*)\right]^2 = \left(\frac{b}{1+b}\right)^2 \left(b^2\sigma_v^2 + \sigma_\varepsilon^2\right)$$

Thus the variance of inflation is increasing in the variance of v, and consequently decreasing in transparency:

$$\frac{\partial V(\pi^*)}{\partial \sigma_v^2} = \left(\frac{b}{1+b}\right)^2 b^2 > 0 \tag{12}$$

The results for output can be derived similarly. The public forms expectations for inflation, $\pi^e = bc$. In equilibrium therefore:

$$y^* = \frac{\varepsilon - bv}{1+b}$$

It is easy to see that $E(y^*) = 0$ and therefore, $\frac{\partial E(y^*)}{\partial \sigma_v^2} = 0$. In addition the variance of equilibrium output is given by:

$$V(y^*) = \frac{\sigma_\varepsilon^2 + b^2\sigma_v^2}{\left(1+b\right)^2}$$

assuming ε and v to be uncorrelated. Hence the variance of output once again decreases with economic transparency.

$$\frac{\partial V(y^*)}{\partial \sigma_v^2} = \frac{b^2}{1+b^2} > 0 \tag{13}$$

2.3 Inattention and constructive ambiguity

Finally, we consider the case when the Central Bank itself is unsure which value of b to apply or is unable to commit itself to one particular value of b for all circumstances. In response to this uncertainty, the private sector supposes that the Central Bank will use β, some fixed number, as its preference parameter. This is the public's best guess or 'consensus estimate'. But, for lack of further information, they are unable to second guess more precisely what value of b will

actually be used. Definition 1 therefore, continues to apply but in contrast to section 2.1, we have

$$\hat{b} = \beta + u \qquad \text{with} \quad E(u) = 0, \quad V(u) = \sigma_u^2 \tag{14}$$

and $E(\hat{b}) = \beta$. Thus the Bank's lack of clarity (possibly ambiguity or inattention) means that $\hat{b}$ must be taken to be a random parameter, while β is fixed[10]. The private sector therefore, expects the CB to implement the following policy:

$$\pi = \beta k - \frac{\beta\varepsilon}{1+\beta}$$

which implies $\pi^e = \beta k$ is the inflation expectation in the markets.

Proposition 3 *If the Central Bank is uncertain about the appropriate weight to give output stabilisation, then an increase in transparency (less ambiguity or less inattention) will lead to higher but less variable inflation rates; and to smaller (that is less negative) but more volatile output gaps. These results hold for conservative central banks, and in certain other cases where the political 'signal to noise' ratio, k/σ_ε, is large. They imply that there will be an optimal level of ambiguity in those cases.*

Proof. The Central Bank knows what the public thinks, and therefore tries to solve

$$\min_{\pi} L = \frac{1}{2} E\left[\pi^2 + \hat{b}\left(\pi - \beta k + \varepsilon - k\right)^2\right] \tag{15}$$

Since π is a choice entirely within the Bank's control, the result is:

$$\pi^* = \frac{\hat{b}\left(1+\beta\right)k}{1+\hat{b}} - \frac{\hat{b}\varepsilon}{1+\hat{b}} \tag{16}$$

But, although this problem may look similar to (4) and (5), it is in fact quite different because $E(\pi^*) \neq \hat{b}k$ or βk, since

$$E\left(\frac{\hat{b}}{1+\hat{b}}\right) \neq \frac{\beta}{1+\beta}$$

[10] This is the assumption used in the existing literature on constructive ambiguity. It says that, for lack of sufficiently accurate information on all the higher order moments of the distribution which the Central Bank may have chosen to use for $\hat{b}$, the private sector will take a first order certainty equivalent (FOCE) estimate of the full Rational Expectations (RE) solution for π^e. Although the resulting solution cannot imply a full RE equilibrium, it does represent the most likely outcome because the deviations from the full RE equilibrium will be second order small. For example, if the private sector was persuaded that the Central Bank was conservative, with $\hat{b}$ distributed roughly normally on the unit interval with 99% certainty, then the FOCE π^e would differ from its RE solution by 3.7% and $E\left(\pi^*\right)$ by 1.2%. Since both errors go the same way, the private sector would then observe an inflation error of 2.5% on average. That is small enough to be ignored. In fact, if the monitoring and "Fed watching" costs were greater than 2.5% of the private sector's research budget, then it would actually be rational to do so. In that sense, this is the right case to study.

even when $E(\hat{b}) = \beta$. In fact, taking expectations, we get approximately, given Jensen's inequality

$$E(\pi^*) = \beta k - \frac{\sigma_u^2 k}{(1+\beta)^2} < \beta k = \pi^e \tag{17}$$

assuming, again, $\hat{b}$ and ε to be independent. Equation (17) has **four** immediate consequences: a) the average level of inflation is affected by imperfect transparency for the first time; b) greater transparency will *increase* average inflation rates; (but from a lower level than before if $\beta = b$); c) the private sector will consistently overestimate inflation; d) the Bank will have an incentive to preserve some ambiguity (incomplete transparency) in this case, since that will put downward pressure on inflationary expectations and hence deliver lower inflation on average. However, the ability to exploit ambiguity in this way will be small if k is small. Unfortunately it will also reduce average output levels, as shown below. Nevertheless, a conservative central bank ($\hat{b} \leq 1$) and a conservative population will regard this lower inflation as the more important gain. Hence we may say that ambiguity is *constructive* in this case. That is in contrast to section 2.1, where there was *no* incentive to use ambiguity or a lack of transparency in a constructive way: $E(\pi)$, $E(y)$ would have been unaffected, and $V(\pi)$ and $V(y)$ would be larger. In the present case however, there will be an *optimal* level of ambiguity if $\hat{b} < 1$ and/or k/σ_ε is not too small[11]. Returning to (16), we can now write

$$V(\pi^*) = (1+\beta)^2 k^2 V\left(\frac{\hat{b}}{1+\hat{b}}\right) + \left[E\left(\frac{\hat{b}}{1+\hat{b}}\right)\right]^2 \sigma_\varepsilon^2 + V\left(\frac{\hat{b}}{1+\hat{b}}\right)\sigma_\varepsilon^2 \tag{18}$$

Evaluating these expectations we get:

$$V(\pi^*) = \frac{k^2\sigma_u^2 + \beta^2\sigma_\varepsilon^2}{(1+\beta)^2} + \frac{\sigma_u^2\sigma_\varepsilon^2}{(1+\beta)^4}\left[1 - 2\beta + \frac{\sigma_u^2}{(1+\beta)^2}\right] \tag{19}$$

and hence

$$\frac{\partial V(\pi^*)}{\partial \sigma_u^2} = \frac{k^2}{(1+\beta)^2} + \frac{(1-2\beta)\,\sigma_\varepsilon^2}{(1+\beta)^4} + \frac{2\sigma_\varepsilon^2\sigma_u^2}{(1+\beta)^6} \tag{20}$$

Thus $\partial V(\pi^*)/\partial\sigma_u^2 \geq 0$, for *all* values of σ_u^2, if

$$\sigma_u^2 \geq \frac{1}{2}(1+\beta)^2\left[2\beta - 1 - k^2\frac{(1+\beta)^2}{\sigma_\varepsilon^2}\right] \tag{21}$$

[11] In such cases, one might suppose that the Central Bank would have an incentive to persuade the public that it was more conserative than it really is, in order to maximise its gains from ambiguity as represented in (17). This is in fact true: a proposition of this kind is demonstrated in Hughes Hallett and Viegi (2003) for the case in which fiscal policies may also be used.

which is certain to hold, for *all* values of σ_u^2, if

$$\frac{k^2}{\sigma_\varepsilon^2} \geq \frac{(2\beta - 1)}{(1+\beta)^2} \quad \text{or if} \quad \beta \leq \frac{1}{2} \tag{22}$$

Consequently, we can conclude that the variability of inflation will, once again, be decreasing with greater transparency (less ambiguity, less inattention etc.) for conservative central banks; and for central banks facing a significant signal to noise (k/σ_ε) ratio. However, to see what happens to output in this case, we return to (16) and (2) where $\pi^e = \beta k$. We have

$$y^* = \frac{\hat{b}(1+\beta)k}{1+\hat{b}} - \frac{\hat{b}\varepsilon}{1+\hat{b}} - \beta k + \varepsilon = \frac{uk+\varepsilon}{1+\hat{b}} \tag{23}$$

This implies, once again, that average output is affected by a lack of clarity:

$$E(y^*) = -\frac{k\sigma_u^2}{(1+\beta)^2} \neq 0 \tag{24}$$

Hence $E(y^*) < 0$, but it *increases* with greater transparency. That is the break on the incentive to create ambiguity in order to lower average inflation rates. Finally, to evaluate output volatility we have

$$(y^* - E(y^*))^2 = \left(\frac{uk+\varepsilon}{1+\hat{b}}\right)^2 + \frac{k^2\sigma_u^4}{(1+\beta)^4} + \frac{2\left(uk^2\sigma_u^2 + \varepsilon k\sigma_u^2\right)}{\left(1+\hat{b}\right)(1+\beta)^2} \tag{25}$$

which leads to

$$\begin{aligned} V(y^*) &= -\frac{k^2\sigma_u^4}{(1+\beta)^4} + \left[\frac{k^2\sigma_u^2 + \sigma_\varepsilon^2}{(1+\beta)^2 + \sigma_u^2}\right]\left[1 + \frac{\sigma_u^2\left[4(1+\beta)^2 - \sigma_u^2\right] + 4\mu_3(1+\beta) + \mu_4}{\left[(1+\beta)^2 + \sigma_u^2\right]^2}\right] \\ &\quad - \frac{k^2\left[2(1+\beta)\mu_3 + \mu_4 - \sigma_u^4\right]}{\left[(1+\beta)^2 + \sigma_u^2\right]^2} \end{aligned} \tag{26}$$

and hence to

$$\begin{aligned} \frac{\partial V(y^*)}{\partial \sigma_u^2} &= \frac{-2k^2\sigma_u^2}{(1+\beta)^4} + \left[\frac{k^2(1+\beta)^2 - \sigma_\varepsilon^2}{\left[(1+\beta)^2 + \sigma_u^2\right]^2}\right]\left[1 + \frac{\sigma_u^2\left[4(1+\beta)^2 - \sigma_u^2\right] + 4\mu_3(1+\beta) + \mu_4}{\left[(1+\beta)^2 + \sigma_u^2\right]^2}\right] \\ &\quad + \left[\frac{k^2\sigma_u^2 + \sigma_\varepsilon^2}{(1+\beta)^2 + \sigma_u^2}\right]\left[\frac{4(1+\beta)^4 - 6(1+\beta)^2\sigma_u^2 - 8\mu_3(1+\beta) - 2\mu_4}{\left[(1+\beta)^2 + \sigma_u^2\right]^3}\right] \\ &\quad + \left[\frac{2k^2\left[\sigma_u^2(1+\beta)^2 + 2(1+\beta)\mu_3 + \mu_4\right]}{\left[(1+\beta)^2 + \sigma_u^2\right]^3}\right] \end{aligned} \tag{27}$$

where μ_3 and μ_4 are respectively the third and fourth moments from $\hat{b}$'s probability density function. To keep things manageable, we assume they are small - as they would be if $\hat{b}$ were normally distributed - and do not increase significantly as σ_u^2 decreases. This may be a poor approximation in some cases; but they must, in any event, vanish as $\sigma_u^2 \to 0$.
Getting conditions to sign this expression uniquely is not possible. However, it is clearly negative for larger values of σ_u^2, as well as when

$$\frac{k^2}{\sigma_\varepsilon^2} \leq \frac{1}{(1+\beta)^2} \tag{28}$$

and if

$$\sigma_u^2 \geq \frac{2}{3}(1+\beta)^2, \text{ or } \sigma_u^2 \geq \frac{2}{3}\frac{\sigma_\varepsilon^2(1+\beta)^2}{k^2}, \text{ or } \sigma_u^2 \geq \frac{0.81(1+\beta)\sigma_\varepsilon^2}{k^2} \tag{29}$$

To obtain (28) and (29) we have used the fact that the second square bracket in (27) is always positive and then found sufficient conditions to make the first, third and fourth terms combined negative[12]. But it is also true that

$$\lim_{\sigma_u^2 \to 0}\left[\frac{\partial V(y^*)}{\partial \sigma_u^2}\right] = k^2 - \frac{\sigma_\varepsilon^2\left((1+\beta)^2 - 4\right)}{(1+\beta)^4} > 0 \quad \text{if} \quad \beta \leq 1 \tag{30}$$

Consequently, output volatility will again *increase* with increasing transparency (clarity) if the signal to noise ratio ($\frac{k^2}{\sigma_\varepsilon^2}$) is not too large, and if β is relatively small when the lack of clarity (σ_u^2) is fairly small. Interestingly, those conditions - which make (27) negative - are very likely to imply that the conditions for $\frac{\partial V(\pi^*)}{\partial \sigma_u^2} > 0$ hold at the same time. This is because (29) implies (21); and, given $\beta \leq 1$, it is then easy to satisfy (22) and (28) simultaneously. Hence, a conservative Central Bank is likely to see the volatility of output rising with greater transparency when the volatility of inflation is falling.

2.4 Commentary

Collecting all these results together, it is useful to note that, as $\sigma_u^2 \to 0$,

$$E(\pi^*) \to \beta k \quad \text{and} \quad E(y^*) \to 0$$

from below (see (17) and (24)). Similarly,

$$V(\pi^*) \to \frac{\beta^2\sigma_\varepsilon^2}{(1+\beta)^2} \quad \text{and} \quad V(y^*) \to \frac{\sigma_\varepsilon^2}{(1+\beta)^2}$$

and that $V(\pi^*)$ approaches its limit from above if (21) holds. Meanwhile

[12] Notice that if (28) holds, then (27) is negative if $\sigma_u^2 > \frac{2}{3}$.

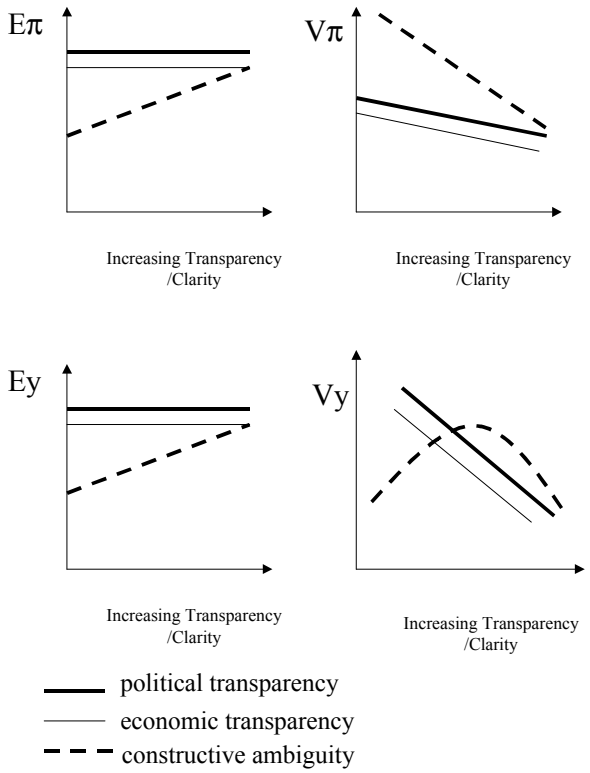

Figure 1:

$$\lim_{\sigma_u^2 \to \infty} = \left[\frac{\partial V(y^*)}{\partial \sigma_u^2}\right] = -\infty \quad \text{and} \quad \lim_{\sigma_u^2 \to 0} = \left[\frac{\partial V(y^*)}{\partial \sigma_u^2}\right] \geq k^2 \quad \text{if} \quad \beta \leq 1$$

so that $V(y^*)$ increases very rapidly when σ_u^2 starts to decline from a high level, but then approaches its limiting value at a faster rate (from above) than its counterpart in (10). In short, we have the situation reported in Figure 1. This makes clear the incentive to retain some degree of ambiguity in this case: it will lead to lower output volatility and lower inflation on average, but at a cost of higher inflation volatility and larger output gap. There is no such incentive to stop short of full clarity with the two models of incomplete transparency.
Conversely, the payoff from greater transparency, past a certain threshold, is a rapid improvement in output stability, a smaller output gap and more stable inflation - but at the cost of higher average rates of inflation.

3 Ambiguity, Inattention and Risk Aversion vs. Imperfect Transparency

3.1 A summary

- There is no advantage, from the CB's point of view, in being less than fully transparent. But there is an advantage in maintaining some ambiguity.
- A lack of transparency, whether political or economic, implies no bias in average inflation or average output levels. Private sector expectations will be correct and average inflation/output will be the same as they would have been under full transparency with the same parameter values. In that respect, it is not a problem that the policy makers or private sector need be concerned about.
- In the short term however, a private sector that believed the Central Bank to be more conservative than it actually is ($\beta < b$ and/or $c < k$), might temporarily experience lower inflation and higher output than otherwise. Conversely, inflation would be temporarily higher and output lower if the CB were thought to be more liberal.
- A lack of transparency does affect the variability of the outcomes however. Incomplete transparency makes both inflation and output more variable but it affects output variability more than it does inflation. Conversely, greater transparency produces more stable output and inflation outcomes, but the larger gains will be in output stability. These results hold equally for both political and economic transparency under a conservative central bank ($b < 1$). But the greater sensitivity of output volatility would be reversed under a liberal Central Bank.
- A lack of transparency,due to the fact that the Central Bank is uncertain about which preference parameters it should use (for reasons of constructive ambiguity or rational inattention perhaps), produces different results. Average inflation will be lower and the output gap larger (a deflationary bias). Similarly, inflation volatility will be higher, and output volatility lower. Unlike the other cases, there may be an incentive to maintain a regime of less than full transparency.

3.2 Why might the Central Bank be Uncertain about which Value of b to Apply?

An unsatisfactory aspect of this story is that it is not obvious why the Central Bank might be unclear about which value of b it should apply. The first two models of imperfect transparency are self-explanatory: the private sector is uncertain about the value of b or k that will be applied, and the Central Bank (being independent) either chooses not to reveal those values to the private

sector, or is unable to do so. But, in the third model, the value of b is selected by the Central Bank and should therefore be known to the Central Bank.

The literature in fact contains a number of models which explain why policy makers may be uncertain about which priorities to set for any particular problem. The first is when their relative priorities (the marginal rates of substitution between π and y) are state dependent. That would happen if the true preferences (over the entire policy space), were more complicated than those represented by a quadratic loss function. In that case, (1) represents a local approximation for the current position of the economy; and being dependent on the uncertain values of π and y, the marginal rate of transformation between them (and the desired value of b) will become a random variable similar to that specified in section 2.3 (Hughes Hallett 1979). The same will happen if policy makers wish to retain an element of risk aversion in their preferences since the strict linear-quadratic framework adopted here will generate risk neutral decisions. There is also a possibility that policy makers cannot always specify their relative priorities in advance, but have to uncover them iteratively by revealed preference[13] (van Eijck and Sandee, 1959). Again b would vary with risk aversion, or the state of the economy.

Modern analysis has provided several more sophisticated reasons why b might be uncertain. The first is to preserve risk sensitivity in a linear-quadratic approach. This can be done by minimising the mean and variance of (1), $\alpha E(L) + (1 - \alpha)V(L)$, where α is a coefficient of risk sensitivity and $V(L)$ is fourth order in π and y (Hughes Hallett, 1984a). That in turn is a truncation of the full risk averse decision making solution devised by Whittle (1982)[14]. From here, it is straight forward to show that risk sensitive decision making is equivalent to having solved the linear-quadratic problem (1) subject to (2), where b is replaced by

$$b\left[\frac{\alpha + (1-\alpha)\, b\sigma_2^2}{\alpha + (1-\alpha)\, b\sigma_1^2}\right]$$

with $\sigma_1^2 = V(y)$ and $\sigma_2^2 = V(\pi)$. If the degree of risk sensitivity α (the curvature of the 'true' preferences) is state dependent, the new value of b will be uncertain *ex ante*.

A second version of this idea is to note that the 'robust control' approach used by Hansen and Sargent (2002), Hansen *et al* (1999), Basar and Bernhard (1995) and others, is equivalent to minimising (1) minus a term in the variance in the state variable y at each point. Again, if the degree of risk sensitivity (the Lagrange multiplier attached to that extra variance term) is state dependent, the implied change to the value of b will be uncertain *ex ante*[15]. But that, as Kasa (2002) points out, is also identical to the model of 'rational inattention'

[13] This would happen for example, if the Central Bank fears it may have to accommodate the government; or if it faces an override clause; or if it wishes to strengthen its accountability or legitimacy.

[14] Hughes Hallett, (1984b).

[15] Note that this change is exactly the same as that in the previous paragraph if the Lagrange

introduced by Sims (2003). The latter problem is one in which policy makers, with a limited capacity to monitor and analyse all the variables in the economy, will rationally reduce the effort made to forecast and control the most variable of them (when there is a lot of variability in the system) in order to concentrate on those that can be controlled. As Sims shows, that is also a problem which can be solved by minimising (1), less a term in the variance of the state variable subject to a monitoring constraint. That implies a one-to-one correspondence with our robust control problem (Kasa, 2002). Hence rational inattention is an other reason for supposing that b would be uncertain *ex ante*.

Further, the best known model of preference uncertainty is the one in which the policy makers deliberately retain 'randomised' preferences in order to exploit the effects of ambiguity in their policies (Cukierman and Meltzer, 1986). Normally this is modelled as a process of control errors in monetary policy. But, in order to generate those errors systematically and to their advantage, policy makers need to create a shift parameter within b, which shifts their preferences between output stabilisation and inflation control in a favourable manner and with suitable timing. Because that shift parameter is random but with persistence, policy makers can affect the speed with which the private sector becomes aware of these shifts. That then allows the Central Bank to choose its moment for monetary policy changes. For example, it may plan a positive surprise to stimulate the economy when output is down; but with expectations lagging and not being certain that is the Bank's intention, the private sector will not anticipate a rise in inflation. The stimulus can therefore, be achieved at lower cost in terms of inflation. Conversely, negative surprises can be timed to reduce inflation without the private sector anticipating a loss in output. But to gain these advantages, the Bank must allow b to be partly uncertain - as in section 2.3.

Lastly and most simply, the case of an uncertain value of b is the case where the Central Bank just fails to correctly anticipate what the private sector thinks. This can be generated by poor two-way communication between the two players, where the central bank is unable to communicate what its intentions are and the private sector, in turn, is at pains to pin down which information is relevant when forming its expectations.

4 Some Empirical Tests

To test the importance of these results in practice, we now confront our theoretical analysis with a panel of data from 9 nine OECD countries over the period 1991-2001. We apply the recently constructed index by Eijffinger and Geraats (2002): see Appendix A for a description of the index. Our objective is to discover whether monetary policy has suffered from transparency or ambi-

multiplier is chosen to be

$$b\left[1-\frac{\alpha+(1-\alpha)\,b\sigma_2^2}{\alpha+(1-\alpha)\,b\sigma_1^2}\right]$$

for some value of α.

guity problems in practice. We therefore regress the transparency index on the average inflation rate and its standard deviation over a specified period for the countries in question; and on the average output gap and its standard deviation for the same sample and group of countries. Naturally, the choice of period considered has to be consistent with the (fixed) institutional set-up underlying the index. Since this varies from country to county, the sample period also differs for each of the nine countries. We give a full description of the data used for each country and the choice of sample in Demertzis and Hughes Hallett (2002). For the present case, figures 2-5 below display the crucial results in the form of cross plots of the average and standard deviation of inflation and the output gap against the index of transparency and the lines of best fit given by the following model:

$$Y_i = \phi + \lambda_{ij} X_j \tag{31}$$

where

Y_i denotes	average inflation, SD of inflation, average output gap, SD of output gap	X_j	indices of political, economic, or total transparency

Parameter λ_{ij} stands for the impact of index j on variable i. The regressions are implemented in univariate terms in order to examine the effect of the index/component in question. The figures included sketch these regressions, their R^2 values and the t statistic for the estimated slope parameter λ_{ij}.

4.1 Empirical Results

- Our empirical results confirm that there is no statistically significant correlation between the index of Central Bank transparency and average inflation rates, or the average output gap for our sample of nine OECD Central Banks. This is consistent with the theoretical predictions of our model. Panel (a) of figures 2 and 3 show the relevant regression results, where the index of transparency is the independent variable and the t-ratio reflects the significance of the slope parameter (critical value: $t_{(8),95\%} = 2.3$).

- It is the variances of inflation and output that are really affected by the degree of Central Bank transparency. This can be seen in panel (b) of figures 2 and 3 which show how increasing transparency stabilises inflation but appears to increase output variability. The former is exactly as predicted by our theoretical analysis; and this result is statistically significant according to the slope coefficient's t-ratio (= 3.06). The latter however, is only consistent with our theory of ambiguity - although it appears to be statistically insignificant at the 10% level.

- It is hard to reach any definitive judgement on whether these results confirm any one of our three models of transparency. On the face of it, at a 5%

confidence level, they are consistent with both imperfect political and economic transparency; average inflation and average output are unaffected by increasing transparency and inflation volatility falls. But output variability is either unaffected (at the 5% confidence level), or it rises instead of falling, if we consider a weaker confidence level. But what it does not do is show any significant evidence of falling with greater transparency, as it should do according to our theory. That suggests the constructive ambiguity, model may in fact be correct, especially if the degree of uncertainty from this form of imperfect transparency (σ_u^2) has been kept relatively small.

- Further, introducing other performance indicators on the right of (31) - e.g. the variance of inflation or average inflation into the output variance relationship – never produced a significant coefficient. It is not necessary therefore, to condition these relationships on any of the variables – for example changes in fiscal policy, commodity or oil price movements, or exchange rate fluctuations – which might otherwise have been thought to influence those relationships (the other indicators standing in as proxies).

- Rerunning these tests on the signs of the correlation coefficients between the index and our various performance indicators to avoid any disputes over the direction of causality between them, produces exactly the same outcomes (see Demertzis and Hughes Hallett, 2002). We have also tried alternative weighting schemes for the different transparency attributes described in table 3 (Appendix A), and aggregated them into two different groups. This did not disturb the results at all: see figures 4 and 5. Similarly, the results remained robust to changes in the list of countries included, and to the type of filter used to determine trend output or inflation. However, going out of a regime period - for example, including date for the UK pre 1997 when the increase in transparency at the Bank of England was introduced - does change the results significantly. All these checks indicate that our results are robust, despite the very small sample.

5 Lessons from our Results

Ambiguity in monetary policy has very different consequences from imperfect transparency. Incomplete transparency (of either kind) has no effect on the average outcomes for inflation or output, but it raises the volatility of both. Constructive ambiguity, by contrast, lowers inflation on average and output volatility (beyond a certain limit), but at the cost of a deflation bias and higher inflation variability. Thus, as Cukierman and Meltzer argue, you might very well want some ambiguity if you wanted to lower inflation (on average) without higher output variability. But you would not want imperfect transparency. Hence those who call for 'a certain degree of (incomplete) transparency'[16], need to make a proper distinction between incomplete transparency and ambiguity.

[16] Issing (1999), Faust and Svensson (2002), Jensen (2002).

The empirical evidence suggests that Central Banks have actually made use of ambiguity, more than they have of incomplete transparency. The lack of a relationship between the index of transparency/clarity and average levels of inflation and output, while there is a significant negative relationship with inflation volatility but a positive one with output variability, would be certainly consistent with the constructive ambiguity hypothesis when the sample size is too small to pick up any significant effects on the average levels. But the other way round does not work. The evidence is not consistent with either model of transparency because, despite no impact on the average levels, we have a zero or positive effect on output variability (instead of a negative one) which cannot be explained away by sample variations[17].

Three conclusions now follow. First, it is important to distinguish between a lack of transparency which occurs when the Central Bank has precise information that it chooses not to reveal to the outside world; and the lack of 'transparency' which arises when the Central Bank does not have precise information itself - for reasons of rational inattention, risk aversion, or constructive ambiguity. What passes for a lack of transparency in conventional discussions could be as much the latter as the former.

Second, the institutional features of monetary policy - for example, independence or the existence and declaration of quantitative targets or inflation forecasts - appear to be less important in practice. More important, evidently, is what follows from the given institutional set up: for example, how it changes the Central Bank's ability to evaluate its own policies, or explain its own strategy and published forecasts. Hence it is the Bank's powers of *communication*, given transparency, which is the sufficient condition for helping the public understand the intentions of the monetary authorities. Independence, targets, forecasts, etc. are only necessary conditions. On the other hand, given the results on output variability, the private sector seems to understand that greater clarity in those intentions may entail some costs in terms of output or employment stability.

Third, we have examined the benefits, or otherwise, of greater transparency – not its cost. There are no costs here to processing the information needed to understand the Bank's intentions (Balke and Haslag, 1992); nor are there any transitory costs in the creation of greater flexibility and lower inflation. This is because we wanted to show the consequences of imperfect transparency, not choose its optimal level.

A different problem remains however. If full transparency is beneficial to the central bank's objectives when full clarity is not, then that must mean that there is scope to manipulate expectations strategically. That would be tantamount to admitting the advantages of time inconsistent behaviour as in effect argued

[17] Moreover, in Demertzis and Hughes Hallett (2002) we found two cases where the positive slope was significant (at the 10% percent level) for the operational transparency component of the index.

by Jensen (2002), Hughes Hallett and Viegi (2003) or Cukierman and Meltzer (1986). Indeed our earlier work has already shown that there is some overlap between the index of transparency and indices of Central Bank independence. On the other hand, a less than full disclosure of its intentions might be a better way for the Central Bank to handle uncertainties in those intentions and their underlying information. Showing the need to deviate from pre-announced intentions in periods of significant uncertainty, having previously insisting on strict precommittment, is not the best way to ensure credibility. It is reasonable to conjecture, therefore, that we will need a theory of good communications in order to separate the concepts of clarity and transparency from credibility. To establish that proposition is the next step in our research.

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APPENDICES

A An Index of Transparency and its components

We use an index of transparency recently constructed by Eijffinger and Geraats, 2002 (henceforth E&G). The index is compiled for nine major central banks and is based on information disclosed by the banks themselves. Furthermore, it distinguishes between various different aspects of transparency, based on the ways in which they affect monetary policy.
The E&G index is defined by the following 15 components of transparency:

Table 1: Transparency Components, E&G Index

1.	Political	2.	Economic
(a)	Formal Objectives	(a)	Economic Data
(b)	Quantitative Targets	(b)	Policy Models
(c)	Institutional Arrangements	(c)	Central Bank Forecasts
3.	Procedural	4.	Policy
(a)	Explicit Strategy	(a)	Prompt announcement
(b)	Minutes	(b)	Policy Explanation
(c)	Voting Records	(c)	Policy Inclination
5.	Operational		
(a)	Control Errors		
(b)	Transmission Disturbances		
(c)	Evaluation Policy Outcomes		

Table 2 below presents the scores obtained for the individual banks, in decreasing order of total transparency:

Table 2 : The E&G Index of Central Bank Transparency (and its components)

	Political	Economic	Procedural	Policy	Operational	Total
New Zealand	3	2.5	3	3	2	13.5
UK	3	2.5	3	1.5	2.5	12.5
Sweden	3	2	2	2	3	12
Canada	3	2.5	1	2	2	10.5
ECB	3	2.5	1	1.5	2	10
US	1	2.5	2	3	1.5	10
Australia	3	1	1	1.5	1.5	8
Japan	1.5	1.5	2	1.5	1.5	8
Switzerland	2.5	1.5	1	2	0.5	7.5

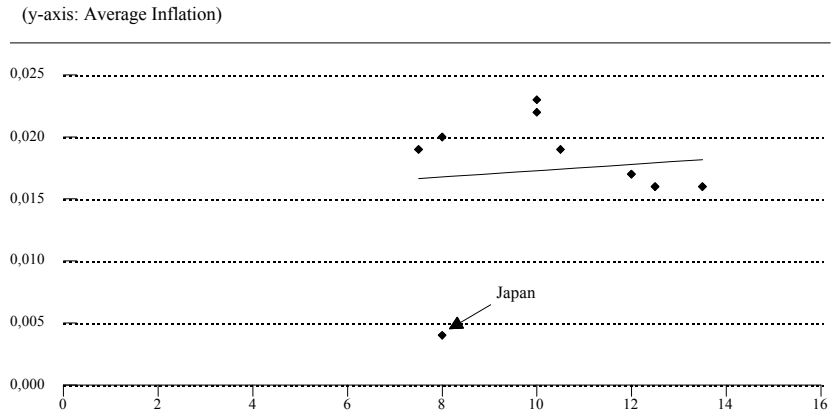
The last column is the arithmetic sum of the individual columns and reflects a measure of total transparency.

A.1 Alternative Weighing Schemes

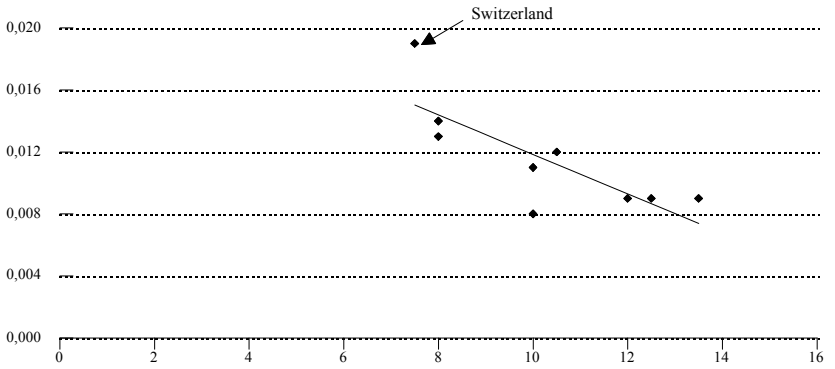
In this section, we use the E&G index again but regroup its components in order to produce an index for economic and political transparency which corresponds to the theoretical model described above. We re-group the components described in Table 1 as follows: *Political Transparency* is now defined as the sum of 1a, 1c, 3a, 3b, 3c, 4a, 4b and 4c and *Economic Transparency* is now defined as the sum of 2a, 2b, 2c, 5a, 5b, 5c and 1b. Category 1b, which captures the existence of a quantitative target, is in our view better placed under the economic definition of transparency. In practice it actually makes very little difference which way the scores under 1b are actually allocated. Table 3 below shows how the different Central Banks score under the new transparency groupings.

Table 3: Alternative Index of Transparency

	Political	Economic	Total
New Zealand	8	5.5	13.5
UK	6.5	6	12.5
Sweden	6	6	12
Canada	5	5.5	10.5
ECB	4.5	5.5	10
US	6	4	10
Australia	4.5	3.5	8
Japan	5	3	8
Switzerland	4.5	3	7.5



(a) Average inflation and total transparency
$R^2 = 0.0104$ t = 0.27



(b) Variance of inflation and total transparency
$R^2 = 0.5728$ t = -3.06

critical values: $t_{(8)\ 95\%} = 2.3$
critical values: $t_{(8)\ 90\%} = 1.8$

Figure 2: Inflation and Transparency

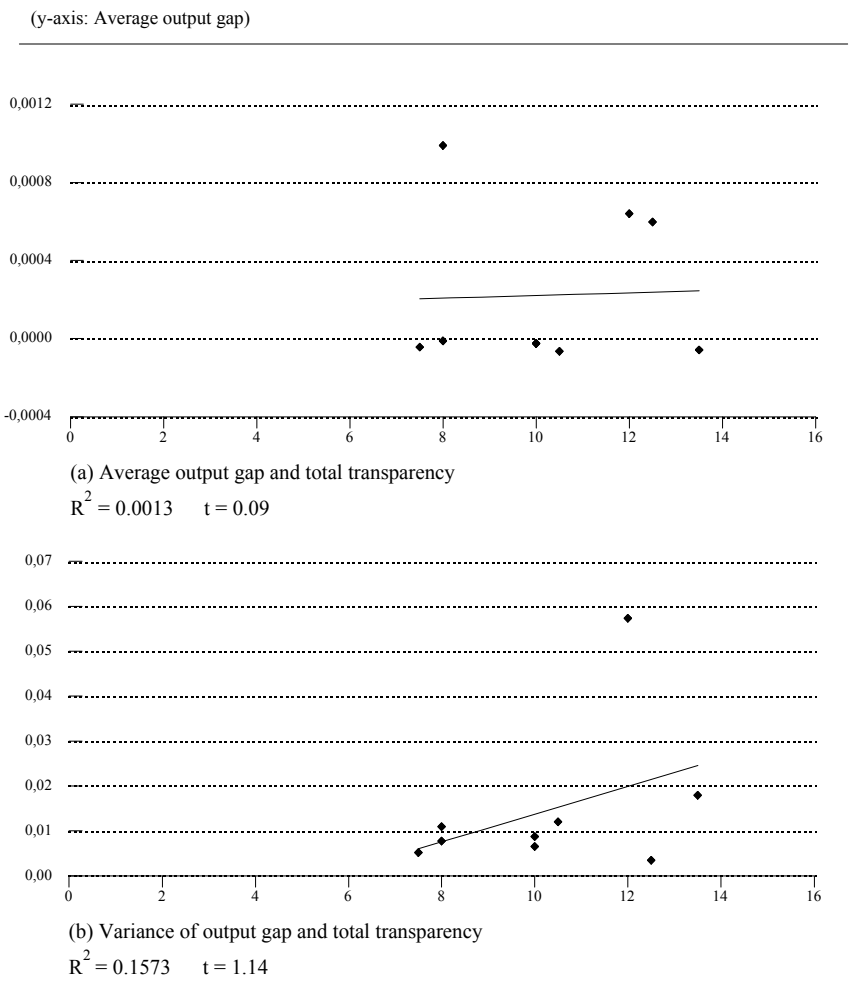


Figure 3: Output and Transparency (HP)*

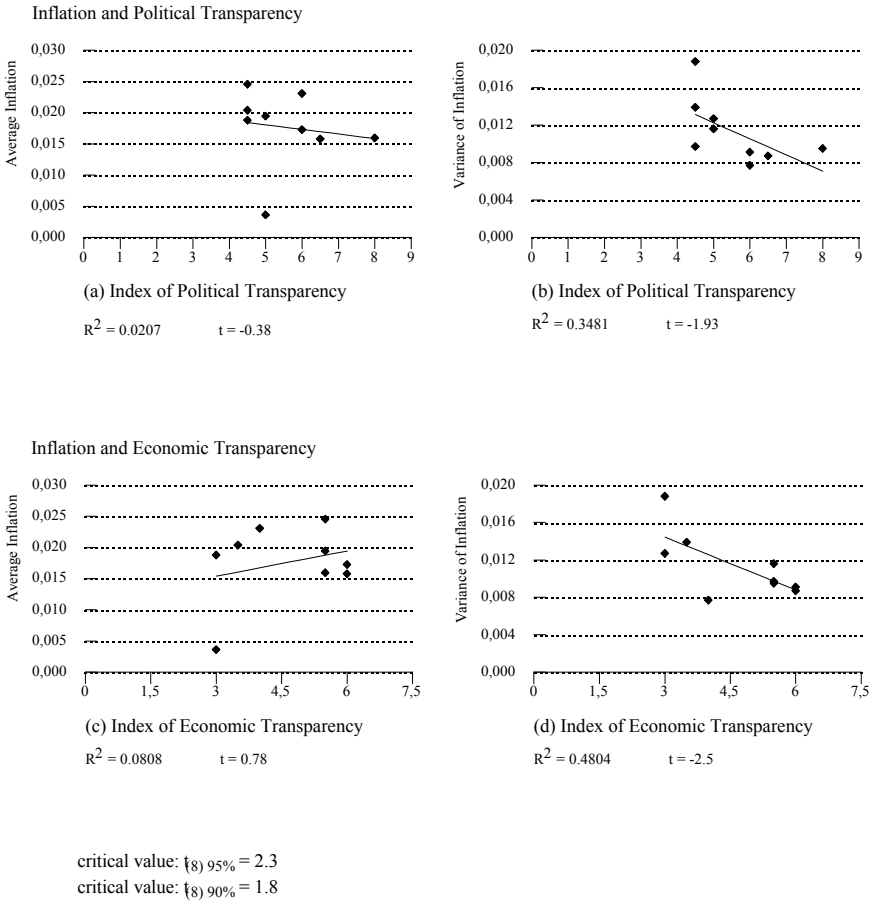


Figure 4: Inflation and alternative definitions of Transparency

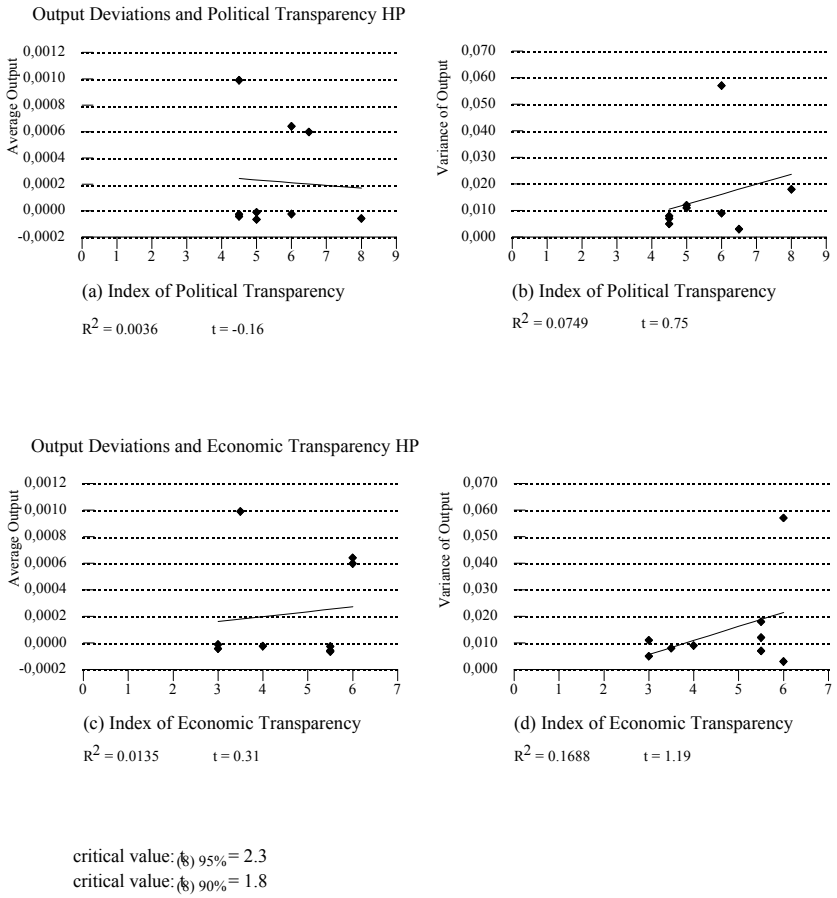


Figure 5: The Output Gap and alternative Definitions of Transparency