Is the Case for Central Bank Secrecy Overstated? The Optimal Stabilization of Nominal Shocks.

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Abstract

A standard result in the central bank transparency literature is that "too much" transparency can impinge on the ability of the central bank to stabilize the economy in the face of nominal shocks. This result is typically obtained in models where the central bank observes the nominal shock, while agents do not. We show that in a more general model, in which both agents and the central bank observe a signal that offers information about the nominal shock, the optimal degree of transparency will be a function of the joint distribution of the nominal shock and the inflation signals observed by agents and the central bank, together with how agents form expectations conditional on the signal they observe. While transparency does undermine the ability of the central bank to conduct stabilisation policy, it also reduces the need for stabilisation policy by reducing the volatility of inflation expectations.

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1. Introduction

There is by now a large and extensive literature outlining the various arguments for and against central bank transparency to which this present paper contributes- see Geraats (2002) for a recent survey. Possible benefits from transparency include assisting a central bank in overcoming credibility problems (Atkeson and Kehoe, 2001), and reducing inflationary bias (Faust and Svensson, 2001). On the other hand, costs may include increased unconditional interest rate volatility (Cosimano and van Huyck (1993), Rudin (1988), Tabellini (1987)), preventing the central bank from introducing surprise inflation when it is most desirable (Cukierman and Meltzer, 1986), increasing inflation uncertainty (Gruner, 2002), inducing the central bank to pay undue attention to nominal rather than real targets (Jensen, 2002), crowding out private information if agents use central bank disclosures as a coordination device (Amato, Morris and Shin, 2003), and reducing the ability of the central bank to stabilise nominal shocks.

This last cost of transparency is the focus of the current paper. A standard result in the central bank transparency literature is that "too much" transparency can impinge on the ability of the central bank to stabilise the economy in the face of nominal shocks, even if it has consistent output and inflation targets so that, on average, the central bank has no incentive to generate surprise inflation. The intuition behind this result, which drops out of standard linear-quadratic models (see Jensen (2000), Cukierman (2001), and Gersbach (2003), for example), is that if a central bank cares about both output and inflation volatility and has knowledge of a nominal shock, the central bank will wish to use monetary policy to optimally apportion the shock between output and inflation volatility; if agents are aware of this, inflation expectations will respond in such a way as to confound the policy of the central bank. Essentially, the optimal stabilisation of nominal shocks requires the generation of short-term surprise inflation or deflation. In contrast, in those same models, transparency about real shocks presents no transparency/ secrecy dilemma for the central bank since the optimal policy in response to a real shock will stabilise both output and inflation. Cukierman (2001) argues that as a result of this cost, a central bank should delay releasing information about future nominal shocks to the public until after inflation expectations have been set, which he labels "limited transparency." Then the central bank should be able to enjoy all the benefits of increased transparency without jeopardising their ability to stabilise the economy.

In the standard model, it is assumed that the central bank observes the nominal shock, while agents do not. In reality, however, both agents and the central bank are likely to have some information about the shock. We generalise the standard model to incorporate this fact, and identify the conditions under which transparency is optimal. In general, if the central bank receives a more informative signal about future inflation than agents, then transparency will serve to reduce the volatility of inflation expectations, and hence inflation.

Central bank transparency about nominal shocks therefore has two offsetting effects on the objective function of the central bank: (i) it undermines the ability of the central bank to conduct stabilisation policy; and (ii) it reduces the volatility of inflation expectations, and therefore inflation. Which of these two effects dominates depends on the joint distribution of the nominal shock and the inflation signals observed by agents and the central bank, and the way in which agents and the central bank form expectations.

To investigate the empirical case for transparency/ secrecy, we calibrate the model to U.S. data using private sector forecasts and Greenbook forecasts as proxies for the inflation signals received by agents and the central bank and show that for these parameter values, the case for transparency for the Federal Reserve is mixed. Although transparency undermines the ability of the central bank to conduct stabilisation policy, the gains due to the reduction in the volatility of agents' inflation expectations may be large enough to offset this.

In the following section, a standard model, incorporating the case for secrecy, is outlined. The new model, incorporating private sector inflation signals, is developed in Section 3. The model is applied to U.S. data in Section 4. Section 5 concludes.

2. The Case for Secrecy

In this section, we develop a simple linear-quadratic model that demonstrates the standard result that the central bank should maintain secrecy regarding nominal shocks. Suppose that inflation is determined by a Phillips curve of the form

$$\pi = \pi^e + \beta y + \epsilon, \tag{1}$$

where π and y are inflation and the output gap respectively, π^e is agents' expectations of inflation, and $\epsilon \sim N(0, \sigma_\epsilon^2)$ is a nominal shock. For simplicity, the central bank is assumed to have complete control over the output gap (y), and sets policy to minimise a loss function given by

$$L = (\pi - \pi^*)^2 + \omega y^2, \tag{2}$$

where π^* represents an inflation target that is assumed to be known by the public. A loss function characterised by $\omega = 0$ represents a central bank that cares only about inflation deviations from target, while for $\omega \to \infty$, the central bank cares only about the output gap. Note that there is no assumed inflation bias here: central banks target an output level that is consistent, on average, with its inflation target.

The central bank is assumed to operate under discretion and observes the shock term, so that optimal monetary policy entails minimising the loss function (2), resulting in a reaction function given by

$$y = \frac{-\beta}{\beta^2 + \omega}(\pi^e - \pi^* + \epsilon). \tag{3}$$

Suppose that agents do not observe ϵ. The solution to the model under secrecy then takes the form

$$\pi^e = \pi^*, \tag{4}$$

$$y = \frac{-\beta}{\beta^2 + \omega}\epsilon, \tag{5}$$

$$\pi = \pi^* + \frac{\omega}{\beta^2 + \omega}\epsilon, \tag{6}$$

$$L_1 = \frac{\omega}{\beta^2 + \omega}\sigma_\epsilon^2. \tag{7}$$

Suppose instead that the central bank were to be transparent about its information set, so that agents observe ϵ. Then

$$\pi^e = \pi^* + \frac{\omega}{\beta^2}\epsilon, \tag{8}$$

$$y = \frac{-1}{\beta}\epsilon, \tag{9}$$

$$\pi = \pi^* + \frac{\omega}{\beta^2}\epsilon, \tag{10}$$

$$L_2 = \frac{\omega(\beta^2 + \omega)}{\beta^4}\sigma_\epsilon^2. \tag{11}$$

It is straight forward to verify that $L_1 < L_2$, so that the central bank would prefer not to be transparent about its information on the inflation shock. This is consistent with results in Jensen (2000), Cukierman (2001), and Gersbach (2003).

3. A More General Model

Note that the above model assumed that agents have no prior information about the size of the inflation shock term, while the central bank has perfect information. Yet casual empiricism would suggest that it is not only central banks that form expectations of future inflation, as is apparent from the abundance of private sector inflation forecasts, a source we will later use to calibrate the model. Suppose that both agents and the central bank observe noisy signals, a and c respectively, of the nominal shock that are jointly distributed, together with the nominal shock, as

$$\begin{pmatrix} a \\ c \\ \epsilon \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_a^2 & \sigma_{ac} & \sigma_{a\epsilon} \\ \sigma_{ac} & \sigma_c^2 & \sigma_{c\epsilon} \\ \sigma_{a\epsilon} & \sigma_{c\epsilon} & \sigma_\epsilon^2 \end{pmatrix}\right). \tag{12}$$

In what follows, it is necessary to define how both agents and the central bank make use of these signals. For the central bank, consistent with its assumed quadratic loss function, I assume that policy conditions on an estimate of ϵ that minimises the mean squared expectational error. That is,

$$y = \frac{-\beta}{\beta^2 + \omega}(\pi^e - \pi^* + \hat{\epsilon}), \tag{13}$$

where $\hat{\epsilon} = (\sigma_{c\epsilon}/\sigma_c^2)c$ minimises $E(\hat{\epsilon} - \epsilon)^2$.[1] Implicitly, I am assuming that the central bank displays some degree of risk aversion in choosing their reaction to their signal.

For agents, their expectations of inflation condition on both their estimate of the nominal shock and also their estimate of the central bank's reaction to its signal of the nominal shock. When thinking about the role of agents' expectations in this model, it is

[1] Strictly, if one considers policy reaction functions that condition on a linear function of c ($\hat{\epsilon} = \alpha c$) and α is chosen so as to minimise the expected loss of the central bank under discretionary policy, $\alpha = \sigma_{c\epsilon}/\sigma_c^2$ results if $C(\pi^e, c) = 0$.

also important to bear in mind that expectations in this model may be thought of as representing the pricing decisions of firms. Essentially we need to make an assumption about firms' objective functions with respect to pricing errors. We consider two alternative assumptions here: (i) agents use their signal to form best linear unbiased expectations (BLUE) of inflation; and (ii) agents use their signals to form inflation expectations that minimise their means square error (MSE). Which of these is more realistic may depend on beliefs about the availability of insurance in the economy. For example, if complete state contingent contracts are available so that firms may insure away losses in efficient markets, then one would expect pricing decisions to be based on unbiased expectations of future nominal shocks, consistent with the BLUE assumption. In contrast, if complete insurance was not available, then firms may be expected to display some degree of risk aversion, consistent with the MSE assumption.

3.1 BLUE Estimation

Suppose the central bank is not transparent, so that agents only observe a. Agents' unbiased estimates of c and ϵ will then be given by $(\sigma_c^2/\sigma_{ac})a$ and $(\sigma_\epsilon^2/\sigma_{a\epsilon})a$ respectively. The model then solves as

$$\pi^e = \pi^* + [\frac{\beta^2+\omega}{\beta^2}\frac{\sigma_\epsilon^2}{\sigma_{a\epsilon}} - \frac{\sigma_{c\epsilon}}{\sigma_{ac}}]a, \tag{14}$$

$$y = \frac{-\beta}{\beta^2+\omega}\left([\frac{\beta^2+\omega}{\beta^2}\frac{\sigma_\epsilon^2}{\sigma_{a\epsilon}} - \frac{\sigma_{c\epsilon}}{\sigma_{ac}}]a + \frac{\sigma_{c\epsilon}}{\sigma_c^2}c\right), \tag{15}$$

$$\pi = \pi^* + \frac{\omega}{\beta+\omega}[\frac{\beta^2+\omega}{\beta^2}\frac{\sigma_\epsilon^2}{\sigma_{a\epsilon}} - \frac{\sigma_{c\epsilon}}{\sigma_{ac}}]a - \frac{\beta^2}{\beta^2+\omega}\frac{\sigma_{c\epsilon}}{\sigma_c^2}c + \epsilon, \tag{16}$$

$$L_1' = \frac{\omega}{\beta+\omega}[\frac{\beta^2+\omega}{\beta^2}\frac{\sigma_\epsilon^2}{\sigma_{a\epsilon}} - \frac{\sigma_{c\epsilon}}{\sigma_{ac}}]^2\sigma_a^2 + \frac{2\omega}{\beta^2+\omega}[\frac{\beta^2+\omega}{\beta^2}\frac{\sigma_\epsilon^2}{\sigma_{a\epsilon}} - \frac{\sigma_{c\epsilon}}{\sigma_{ac}}]\sigma_{a\epsilon} - \frac{\beta^2}{\beta^2+\omega}\frac{(\sigma_{c\epsilon})^2}{\sigma_c^2} + \sigma_\epsilon^2. \tag{17}$$

Suppose instead that the central bank is transparent, so that agents observe both a and c. Now agents' BLUE estimate of ϵ will minimise $V(\hat{\epsilon}-\epsilon)$ subject to the restriction that $E(\hat{\epsilon}) = \epsilon$. This is given by

$$\hat{\epsilon} = \frac{\sigma_\epsilon^2\big([\sigma_c^2\sigma_{a\epsilon} - \sigma_{ac}\sigma_{c\epsilon}]a + [\sigma_a^2\sigma_{c\epsilon} - \sigma_{ac}\sigma_{a\epsilon}]c\big)}{\sigma_a^2(\sigma_{c\epsilon})^2 + \sigma_c^2(\sigma_{a\epsilon})^2 - 2\sigma_{ac}\sigma_{a\epsilon}\sigma_{c\epsilon}}, \tag{18}$$

where

$$V(\hat{\epsilon}) = \frac{(\sigma_\epsilon^2)^2(\sigma_a^2\sigma_c^2 - (\sigma_{ac})^2)}{\sigma_a^2(\sigma_{c\epsilon})^2 + \sigma_c^2(\sigma_{a\epsilon})^2 - 2\sigma_{ac}\sigma_{a\epsilon}\sigma_{c\epsilon}}, \tag{19}$$

and $C(\hat{\epsilon}, c) = (\sigma_{c\epsilon}/\sigma_\epsilon^2)V(\hat{\epsilon})$, $C(\hat{\epsilon}, \epsilon) = \sigma_\epsilon^2$. The model then solves as

$$\pi^e = \pi^* + \frac{\beta^2 + \omega}{\beta^2}\hat{\epsilon} - \frac{\sigma_{c\epsilon}}{\sigma_c^2}c, \tag{20}$$

$$y = \frac{-1}{\beta}\hat{\epsilon}, \tag{21}$$

$$\pi = \pi^* + \frac{\omega}{\beta^2}\hat{\epsilon} - \frac{\sigma_{c\epsilon}}{\sigma_c^2}c + \epsilon, \tag{22}$$

$$L_2' = \frac{\omega(\beta^2 + \omega)}{\beta^4}V(\hat{\epsilon}) - \frac{2\omega}{\beta^2}\frac{\sigma_{c\epsilon}}{\sigma_c^2}C(\hat{\epsilon}, c) - \frac{(\sigma_{c\epsilon})^2}{\sigma_c^2} + \frac{2\omega}{\beta^2}\sigma_\epsilon^2 + \sigma_\epsilon^2. \tag{23}$$

3.2 MSE Estimation

Suppose instead that agents' form estimates of the nominal shock and of the central bank's signal that minimise their mean square errors. In general, this will imply estimates that are biased towards zero, as agents observe the shock with error. For example, agents observing only a will form an expectation of ϵ (labelled $\hat{\epsilon}$) that minimises $E(\hat{\epsilon} - \epsilon)^2$ given by $\hat{\epsilon} = (\sigma_{a\epsilon}/\sigma_a^2)a$. Comparing this with the BLUE case above, the estimate will be systematically biased towards zero for $\sigma_\epsilon^2\sigma_a^2 > (\sigma_{a\epsilon})^2$, which in general will hold.

Now suppose that the central bank were to choose not to publish forecasts. Then the model solves as

$$\pi^e = \pi^* + [\frac{\beta^2 + \omega}{\beta^2}\frac{\sigma_{a\epsilon}}{\sigma_a^2} - \frac{\sigma_{ac}\sigma_{c\epsilon}}{\sigma_a^2\sigma_c^2}]a, \tag{24}$$

$$y = \frac{-\beta}{\beta^2 + \omega}\big([\frac{\beta^2 + \omega}{\beta^2}\frac{\sigma_{a\epsilon}}{\sigma_a^2} - \frac{\sigma_{ac}\sigma_{c\epsilon}}{\sigma_a^2\sigma_c^2}]a + \frac{\sigma_{c\epsilon}}{\sigma_c^2}c\big), \tag{25}$$

$$\pi = \pi^* + \frac{\omega}{\beta^2+\omega}[\frac{\beta^2+\omega}{\beta^2}\frac{\sigma_{a\epsilon}}{\sigma_a^2} - \frac{\sigma_{ac}\sigma_{c\epsilon}}{\sigma_a^2\sigma_c^2}]a - \frac{\beta^2}{\beta^2+\omega}\frac{\sigma_{c\epsilon}}{\sigma_c^2}c + \epsilon, \tag{26}$$

$$\begin{aligned} L_1'' =& \frac{\omega}{\beta^2+\omega}[\frac{\beta^2+\omega}{\beta^2}\frac{\sigma_{a\epsilon}}{\sigma_a^2} - \frac{\sigma_{ac}\sigma_{c\epsilon}}{\sigma_a^2\sigma_c^2}]^2\sigma_a^2 + \frac{2\omega}{\beta^2+\omega}[\frac{\beta^2+\omega}{\beta^2}\frac{\sigma_{a\epsilon}}{\sigma_a^2} - \frac{\sigma_{ac}\sigma_{c\epsilon}}{\sigma_a^2\sigma_c^2}]\sigma_{a\epsilon} \\ &- \frac{\beta^2}{\beta^2+\omega}\frac{(\sigma_{c\epsilon})^2}{\sigma_c^2} + \sigma_\epsilon^2. \end{aligned} \tag{27}$$

Next, consider the case where the central bank is transparent so that agents observe both a and c. Now agents' estimate of ϵ will satisfy

$$\hat{\epsilon} = \frac{(\sigma_{a\epsilon}\sigma_c^2 - \sigma_{c\epsilon}\sigma_{ac})a + (\sigma_{c\epsilon}\sigma_a^2 - \sigma_{a\epsilon}\sigma_{ac})c}{\sigma_a^2\sigma_c^2 - (\sigma_{ac})^2}, \tag{28}$$

where

$$V(\hat{\epsilon}) = \frac{\sigma_a^2(\sigma_{c\epsilon})^2 + \sigma_c^2(\sigma_{a\epsilon})^2 - 2\sigma_{ac}\sigma_{a\epsilon}\sigma_{c\epsilon}}{\sigma_a^2\sigma_c^2 - (\sigma_{ac})^2}, \tag{29}$$

$C(\hat{\epsilon}, \epsilon) = V(\hat{\epsilon})$, $C(\hat{\epsilon}, c) = \sigma_{c\epsilon}$. The model then solves as

$$\pi^e = \pi^* + \frac{(\beta^2+\omega)}{\beta^2}\hat{\epsilon} - \frac{\sigma_{c\epsilon}}{\sigma_c^2}c, \tag{30}$$

$$y = \frac{-1}{\beta}\hat{\epsilon}, \tag{31}$$

$$\pi = \pi^* + \frac{\omega}{\beta^2}\hat{\epsilon} - \frac{\sigma_{c\epsilon}}{\sigma_c^2}c + \epsilon, \tag{32}$$

$$L_2'' = \frac{\omega(\beta^2+\omega)}{\beta^4}V(\hat{\epsilon}) - \frac{2\omega}{\beta^2}\frac{\sigma_{c\epsilon}}{\sigma_c^2}C(\hat{\epsilon}, c) + \frac{2\omega}{\beta^2}C(\hat{\epsilon}, \epsilon) - \frac{(\sigma_{c\epsilon})^2}{\sigma_c^2} + \sigma_\epsilon^2. \tag{33}$$

3.3 Some Examples

There are a number of interesting examples that we will now use to illustrate the range of possible results in this model. First note that the example given in Section 2 is a special case of the MSE model, in particular with $\sigma_\epsilon^2 = \sigma_c^2 = \sigma_{c\epsilon}$ and $\sigma_a^2 \to \infty$.

More generally, the results may be sensitive to the parameter values in (12). Elsewhere, authors have uncovered some information about the parameters, at least for the

United States. Joutz and Stekler (2000) demonstrate that the Federal Reserve produces more accurate forecasts than commercial forecasters for a variety of variables, over a range of different horizons. Romer and Romer (2000) also find that Federal Reserve forecasts contain additional information over commercial forecasts, most notably at horizons of about 4 quarters. They argue that the information advantage is so great that, if they had the choice, commercial forecasters would be best off basically discarding their own forecasts and adopting those of the Federal Reserve. They suggest that this information advantage is because the Federal Reserve commits more resources to forecasting than any single commercial forecaster. Others have argued that, because of their institutional nature, central banks should know more, and therefore produce more accurate forecasts. Not only do they face less uncertainty as to their own future policy actions, but, as Peek, Rosengren, and Tootell (1999) have shown, they typically have access to confidential bank supervisory data that contains information that is useful for macroeconomic forecasting.

We now consider two examples broadly consistent with this empirical evidence, where the optimal forecast of inflation that combined both the forecasts of agents and the central bank would place complete weight on the central bank's forecast. Suppose, for example, that the signals observed by both agents and the central bank contain full information about the nominal shock, but are noisy indicators, with the signal of agents containing additional white noise than the central bank's, so that $\sigma_a^2 > \sigma_c^2 = \sigma_{ac} > \sigma_{a\epsilon} = \sigma_{c\epsilon} = \sigma_\epsilon^2$. With the BLUE assumption, it follows from (17) and (23) that

$$L_1' - L_2' = \frac{\omega(\sigma_a^2 - \sigma_c^2)}{\beta^4(\beta^2 + \omega)}\left[(\beta^2 + \omega) - \beta^2 \frac{\sigma_\epsilon^2}{\sigma_c^2}\right]^2 > 0, \tag{34}$$

indicating that transparency is optimal.

Under the same assumptions about (12), but assuming the MSE model, simplifying equations (27) and (33) yields

$$L_1'' - L_2'' = \frac{\omega^2(\sigma_\epsilon^2)^2(\omega + 2\beta^2)(\sigma_c^2 - \sigma_a^2)}{\beta^4(\beta^2 + \omega)\sigma_a^2\sigma_c^2} < 0, \tag{35}$$

indicating that secrecy is optimal.

As an additional example, also consistent with Romer and Romer's (2000) observation, suppose that

$$\epsilon = \sum_{i=0}^{I} \nu_i, \tag{36}$$

where ν_i is an independently and identically distributed variable. Assume further that agents observe the first m draws on ν_i, while the central bank observes the first $n > m$ draws. Then it follows that $\sigma_\epsilon^2 > \sigma_c^2 = \sigma_{c\epsilon} > \sigma_a^2 = \sigma_{ac} = \sigma_{a\epsilon}$. Now, assuming the BLUE model,

$$L_1' - L_2' = \frac{\omega(\sigma_c^2 - \sigma_a^2)}{\beta^4(\beta^2 + \omega)\sigma_a^2\sigma_c^2}\left[\omega\sigma_\epsilon^2 + \beta^2(\sigma_\epsilon^2 - \sigma_c^2)\right]^2, \tag{37}$$

which is unambiguously positive, implying that transparency is optimal. In contrast, assuming the MSE model,

$$L_1'' - L_2'' = \frac{\omega^2(\omega + 2\beta^2)(\sigma_a^2 - \sigma_c^2)}{\beta^4(\beta^2 + \omega)}, \tag{38}$$

which is unambiguously negative, implying that secrecy is optimal.

These examples serve to illustrate that whether a central bank should be transparent about nominal shocks depends on the joint distribution of those shocks and signals that agents receive of those shocks, but more crucially, on assumptions about how agents make use of noisy signals about shocks. In two very different examples, both broadly consistent with the empirical evidence in Romer and Romer (2000), the BLUE model would indicate that transparency is generally desirable, and the MSE model that transparency is not. However, parameter values exist for which the reverse holds true. In the next section, we therefore calibrate the model to U.S. data to see if the results are robust.

4. New Empirical Evidence

So which is more realistic? In this section, we seek to calibrate the model using official forecasts of the Federal Reserve taken from the Greenbook and private sector forecasts taken from the Survey of Professional Forecasters. First it is important to outline the assumptions underpinning the interpretation of "nominal shocks" used here. The standard linear-quadratic model that is the basis of the above analysis is a reduced-form macroeconomic model; if interpreted as a structural model, then neither the central bank nor agents may be expected to possess information about future random shocks to impact the economy. Interpreted as a reduced form model, however, a nominal shock should be interpreted as any nominal event that, left unchecked, will drive inflation away from its target. Given the degree of persistence observed in nominal processes, a substantial portion of the shock is pre-determined, and agents and the central bank are both likely to have reasonably precise estimates of future nominal shocks.

In order to interpret the inflation forecasts as representing the private indicators of nominal shocks, we are also assuming that the primary source of inflation deviations are nominal, rather than reflecting the optimal monetary policy response to real shocks. The next assumption we need to make is what exactly the published forecasts represent. There are two possibilities that we consider: (i) they represent the signals observed by agents and the central bank (a and c respectively); and (ii) they present means square error minimising estimates of future inflation. Under (i), the parameter values in (12) can be derived directly from the variance covariance matrix of the three series. Under (ii), $f_a = (\sigma_{a\epsilon}/\sigma_a^2)a$ and $f_c = (\sigma_{c\epsilon}/\sigma_c^2)c$ respectively, yielding

$$V(f_a) = C(f_a, \epsilon) = \frac{(\sigma_{a\epsilon})^2}{\sigma_a^2};\; V(f_c) = C(f_c, \epsilon) = \frac{(\sigma_{c\epsilon})^2}{\sigma_c^2};$$

$$C(f_a, f_c) = \frac{\sigma_{a\epsilon}\sigma_{c\epsilon}\sigma_{ac}}{\sigma_a^2\sigma_c^2};\; V(\epsilon) = \sigma_\epsilon^2. \tag{39}$$

Only four of the six variables in (12) may be identified by the second order moments, while the final two may be identified using the first order moments. We therefore use Maximum Likelihood estimation to obtain estimates of the parameters of (12).

The forecast data for both the Federal Reserve and the Survey of Professional Forecasters are drawn from the Federal Reserve Bank of Philadelphia home page (http://www.phil.frb.org/econ/forecast/index.html), where median forecasts from the SPF are considered. Realised inflation is taken from the Federal Reserve Bank of St Louis home page (http://research.stlouisfed.org/fred2/). For each variable, the measure of inflation used is the GNP deflator from 1965-1991, and the GDP deflator starting in 1992.

We are interested in the respective signals observed by agents and the central bank at horizons over which prices will be relatively responsive and monetary policy has an effect on the economy, following lags in the monetary transmission mechanism. We therefore consider forecasts made 2-4 quarters ahead, over the longest available sample of 1968Q4 - 1996Q4. One final step we take is removing the average rate of inflation from each of the variables.[2]

[2] In principle one could allow for a separate average for each variable (so that the estimates are equivalent to computing a centred variance-covariance matrix). Doing so makes very little difference to the reported

The results where published forecasts are interpreted as representing the signals observed by agents and the central bank (a and c respectively) are given in the top panel of Table 1, for $\omega = 1$ and $\beta = 1$. Broadly speaking, the results seem consistent with the second example outlined in section 3 that implies that the central bank knows everything that private sector forecasters know, plus additional relevant information ($\sigma_\epsilon^2 > \sigma_c^2 = \sigma_{c\epsilon} > \sigma_a^2 = \sigma_{ac} = \sigma_{a\epsilon}$). While central bank forecasts were generally more volatile than private sector forecasts, they were also more highly correlated with realised inflation. Not surprisingly, the conclusions for transparency are also consistent with this example: if agents' expectations are based on BLU estimates of inflation shocks, then the central bank should be transparent: the resulting drop in the volatility of inflation expectations more than offsets any loss in ability to conduct stabilisation policy. In contrast, if agents' expectations minimise their means square error, then the central bank should not be transparent. Similar results are obtained if we break down the data by decade to allow for structural breaks in inflation (results not reported).

The second panel of Table 1 contains results based on the assumption that forecasts of the Federal Reserve and the private sector are functions of the observed signals that minimize the expected mean square error in estimating inflation. Note that we can then rewrite (12), including mean inflation, as

$$\begin{pmatrix} \frac{\sigma_{a\epsilon} f_a}{\sigma_\epsilon^2} \\ \frac{\sigma_{c\epsilon} f_c}{\sigma_\epsilon^2} \\ \epsilon \end{pmatrix} \sim N\left(\begin{pmatrix} \bar{\pi} \\ \bar{\pi} \\ \bar{\pi} \end{pmatrix}, \begin{pmatrix} \sigma_a^2 & \sigma_{ac} & \sigma_{a\epsilon} \\ \sigma_{ac} & \sigma_c^2 & \sigma_{c\epsilon} \\ \sigma_{a\epsilon} & \sigma_{c\epsilon} & \sigma_\epsilon^2 \end{pmatrix} \right), \tag{40}$$

or equivalently $y \sim N(0, \Sigma)$. Then the parameter estimates will be chosen so as to

results, and removing a common mean cannot be rejected empirically. This is because both private sector and Federal Reserve forecasts exhibit little bias on average.

maximize the loglikelihood function

$$L = \frac{-N}{2} ln|\Sigma| - \frac{1}{2}\sum_{n=1}^{N} y'\Sigma^{-1}y. \tag{41}$$

Note that once again, when we consider the desirability of transparency, if agents' expectations are based on BLU estimates of inflation shocks, transparency is optimal, while if they are based on MSE- minimizing estimates of inflation shocks, secrecy is optimal. Note however that these results should be interpreted with caution: the variance covariance matrix is close to singular in this case, and some of the coefficients are very sensitive to minor perturbations in the data.

So what is the appropriate way in which to interpret central bank forecasts? One possible way to determine this would be to allow forecasts to be a combination of the observed signal and a MSE minimizing function of that signal, and estimate the relative weights on each. If indeed (12) represents the data generating process of the signals observed by both agents and the central bank, this test should provide a way to illuminate the appropriate way to interpret forecasts.

The third panel of Table 1 contains the estimates of a_0 and c_0 where $f_a = [a_0 + (1-a_0)(\sigma_{a\epsilon}/\sigma_a^2)]a$ and $f_c = [c_0 + (1-c_0)(\sigma_{c\epsilon}/\sigma_c^2)]c$ respectively. Note that this nests the interpretation of forecasts as the observed signals ($a_0 = c_0 = 1$) and MSE minimizing functions of those signals ($a_0 = c_0 = 0$). In all cases, the point estimates for a_0 and c_0 are close to zero, supporting the MSE model as the appropriate framework for understanding forecasts. Note, however, that both the BLU and MSE models may be easily rejected using likelihood ratio tests against a more general alternative. However, this again may be purely a result of the near-singularity of Σ.

Tables 2 and 3 consider cases where the central bank places a higher weight on inflation stability ($\omega = 0.1$) and output stability ($\omega = 10$) respectively. The results here again support the idea that if agents' expectations are based on BLU estimates of inflation shocks, transparency is optimal, while if they are based on MSE- minimizing estimates of inflation shocks, secrecy is optimal.

5. Conclusions

A standard result in the central bank transparency literature is that "too much" transparency can impinge on the ability of the central bank to stabilise the economy in the face of nominal shocks. We show that this result hinges on the assumption that the central bank observes the nominal shock, while agents do not. If instead agents and the central bank both observe the shock with error, then the optimal degree of transparency will be a function of the joint distribution of the nominal shock and the inflation signals observed by agents and the central bank, together with how agents form expectations conditional on the signals they observe.

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Table 1: Estimated Signal Parameters and Optimal Transparency; ω=1.0

Forecasts	Estimate	2 quarter	3 quarter	4 quarter
$f_a=a$	σ^2_a	3.06	2.94	3.18
$f_c=c$	σ^2_c	4.05	3.98	3.78
	σ^2_ε	6.39	6.53	6.61
	σ_{ac}	3.28	3.10	3.17
	$\sigma_{a\varepsilon}$	2.94	2.57	2.59
	$\sigma_{c\varepsilon}$	3.80	3.70	3.55
	$L_1'-L_2'$	4.04	9.63	12.13
	$L_1''-L_2''$	-1.62	-3.02	-3.57
$f_a=(\sigma_{a\varepsilon}/\sigma^2_a)a$	σ^2_a	0.00	0.00	0.00
$f_c=(\sigma_{c\varepsilon}/\sigma^2_c)c$	σ^2_c	0.04	0.01	0.00
	σ^2_ε	8.49	11.15	9.77
	σ_{ac}	0.00	0.00	0.00
	$\sigma_{a\varepsilon}$	0.00	0.00	0.00
	$\sigma_{c\varepsilon}$	0.47	0.28	0.04
	$L_1'-L_2'$	1.35	3.90	2.19
	$L_1''-L_2''$	-0.91	-3.38	-1.56
$f_a=[a_0+(1-a_0)(\sigma_{a\varepsilon}/\sigma^2_a)]a$	a_0	0.00	0.00	0.00
$f_c=[c_0+(1-c_0)(\sigma_{c\varepsilon}/\sigma^2_c)]c$	c_0	-0.09	-0.04	-0.01
	logl	1591	1472	1598
	logl($a_0=0,c_0=0$)	1121	1175	1287
	logl($a_0=1,c_0=1$)	-254	-257	-232

Table 2: Estimated Signal Parameters and Optimal Transparency; ω=0.1

Forecasts	Estimate	2 quarter	3 quarter	4 quarter
$f_a=a$	$L_1'-L_2'$	0.15	0.38	0.49
$f_c=c$	$L_1''-L_2''$	-0.06	-0.13	-0.17
$f_a=(\sigma_{a\varepsilon}/\sigma^2_a)a$	$L_1'-L_2'$	0.04	0.14	0.07
$f_c=(\sigma_{c\varepsilon}/\sigma^2_c)c$	$L_1''-L_2''$	-0.02	-0.15	-0.05

Table 3: Estimated Signal Parameters and Optimal Transparency; ω=10

Forecasts	Estimate	2 quarter	3 quarter	4 quarter
$f_a=a$	$L_1'-L_2'$	326.25	732.67	898.61
$f_c=c$	$L_1''-L_2''$	-91.93	-157.91	-176.87
$f_a=(\sigma_{a\varepsilon}/\sigma^2_a)a$	$L_1'-L_2'$	133.93	341.07	198.20
$f_c=(\sigma_{c\varepsilon}/\sigma^2_c)c$	$L_1''-L_2''$	-61.00	-174.14	-91.72