The Role of Transparency as a Mechanism for Accountability

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Abstract

In this paper, I revisit an old question first studied by Rogoff (1984) – should central banks pursue objectives that differ systematically from social welfare? And if so, how is the answer to this question affected by the degree of transparency that characterizes monetary policy? When a central bank is not transparent, changes in the policy interest rate have informational effects that distort the central bank's incentives. Making the central bank more accountable for inflation stablization can offset this distortion and lead to lower social loss. The objectives of a transparent central bank, however, should not differ from those of society. Outcomes under transparency may, however, be dominated by those produced by an opaque and conservative central bank.

1 Introduction

Monetary policy involves the delegation of important policy authority to a quasi-independent agency of the government. A large literature has argued for the benefits that independence brings to the conduct of monetary policy, but at the same time, democratic societies have a right to expect that accountability should accompany independence. One means for ensuring accountability is to assign performance measures or benchmarks against which

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the central bank's performance can be judged. Inflation targeting regimes in which an explicit inflation target is announced do just that.

In this paper, I revisit an old question first studied by Rogoff (1984) – should central banks pursue objectives that differ systematically from social welfare? And if so, how is the answer to this question affected by the degree of transparency that characterizes the policy framework? When a central bank is not transparent, policy actions such as a change in the policy interest rate have informational effects as the private sector uses the interest rate to infer the central bank's outlook for the economy. This informational effect distorts the central bank's response to shocks, a common feature of models with asymmetric information (Geraats 2002). Making the central bank more accountable for inflation stabilization can offset this distortion and lead to lower social loss. The objectives of a transparent central bank, however, should not differ from those of society.

The basic model, described in the following section, is similar to the one employed in Walsh (2007a-c). A key component of the model is the presence of heterogeneous information among private firms as well as information asymmetries between the private sector and the central bank. A fraction of firms adjust prices each period, and these firms must forecast both demand and cost conditions but also what other firms are doing. This introduces the need to form expectations of what others are expecting along the lines originally analyzed by Morris and Shin (2002). The role of heterogeneous information has been explored by Woodford (2003), Hellwig (2002), and Amato and Shin (2003), Svensson (2006), and Fukunaga (2007).

Walsh (2007a,b) investigated the optimality of partial transparency in the sense of Heinnman and Cornad (2005). The model of this paper is similar to Walsh (2007c) but in that paper, I did not investigate the optimal weight on inflation to assign the central bank. In addition, an innovation of the present paper is the introduction of a way to distinguish between the role of heterogeneous private sector information and asymmetric information between the central bank and the private sector.

The next section develops the model. Equilibrium with an opaque central bank is analyzed in section 3. Section 4 addresses the issue of whether an opaque central bank should be held more accountable for stabilizing inflation. Outcomes under the different opaque policy regimes are compared to those achieved when the central bank is transparent in section 5. Section 6 concludes.

2 The model

The basic model incorporates nominal rigidities, through a standard Calvo-type model of price setting by monopolisticly competitive firms, and informational asymmetries, between both the private sector and the central bank and among private sector firms. The specification in this paper allows for the effects of asymmetric information and heterogeneous information among private agents to be separately studied. I focus on economic transparency, modelled as different assessments of the underlying state of the economy by the central bank and private firms. These differences could arise if private agents and the central bank have different information about the economy, but they could also arise from differences in the models used to generate forecasts or simply from the role of judgement factors that influence both the central bank's and the private sector's assessment of future economic developments.

Since the information aspects of the model are critical, I describe them first. There are a continuum of differentiated firms operating in an environment characterized by monopolistic competition. Each firm receives private information on the fundamental shocks. The information on the time $t+1$ realization of shock i received by firm j at time t is denoted by $e^i_{j,t+1}$. This signal is related to the true realization e^i_{t+1} by

$$e^i_{j,t+1} = e^i_{t+1} + (1-\alpha)\phi^i_{t+1} + \alpha\phi^i_{j,t+1}, \tag{1}$$

where ϕ^i is a measurement error common to all firms and ϕ^i_j is a firm j idiosyncratic error. If $\alpha = 1$, we have the Morris and Shin (2002) case; the noise in the firm's signal is firm-specific, private information. If $\alpha = 0$, private information is common, so the only informational imperfection would be the asymmetric information between the private sector and the central bank.

Similar to firms, the central bank receives information about the shocks:

$$e^i_{cb,t+1} = e^i_{t+1} + \phi^i_{cb,t+1}. \tag{2}$$

All shocks and noise are assumed to be independently distributed and serially uncorrelated.

While it is convenient for modelling purposes to structure the information in terms of signals, it is important to recognize that these can be given a much more general (and potentially realistic) interpretation. For example, let

$$\gamma^i_{cb} = \frac{\sigma^2_i}{\sigma^2_i + \sigma^2_{cb,i}}$$

be the central bank's signal to noise ratio for shock i (σ^2_i is the variance of e^i and $\sigma^2_{cb,i}$ is the variance of ϕ^i_{cb}). Then the central bank's forecast of e^i_{t+1} is

$$E^{cb}_t e^i_{t+1} = \gamma^i_{cb} e^i_{cb,t+1}.$$

Since the rational expectations of the model will presume that private agents know the quality of the central bank's information (i.e., they know γ^i_{cb}), we could equivalent talk about the central bank's forecast of future economic developments rather than the signals it receives.

Firms adjust prices according to the Calvo representation of sticky prices. Those firms able to adjust set their price for period $t+1$ based on time t information and the new information they receive about $t+1$ shocks. It is convenient to express the optimal price set by firm j relative to the time t price level as (see Walsh 2007b)

$$\pi^*_{j,t+1} = (1-\omega)E^j_t\bar{\pi}^*_{t+1} + (1-\omega\beta)\left(\kappa E^j_t x_{t+1} + E^j_t e^s_{t+1}\right) + \left(\frac{\omega\beta}{1-\omega}\right) E^j_t \pi_{t+2}, \tag{3}$$

where $\pi^*_{j,t+1} = p^*_{j,t+1} - p_t$ is the optimal adjustment by firm j, $\bar{\pi}^*_{t+1}$ is the average price adjustment across all firms allowed to reset their prices in period t. In the standard common information framework, $\pi^*_{j,t+1} = \bar{\pi}^*_{t+1}$ for all j as all firms are identical. Note that in this case, (3) reduces to a standard new Keynesian Phillips curve with Christiano, Eichenbaum, and Evans (2005) timing. Information sets may differ; thus, the operator E^j reflects expectations condition on firm $j's$ information. The firm's optimal price depends on its forecasts of the output gap, $E^j_t x_{t+1}$, and the cost shock $E^j_t e^s_{t+1}$. Finally, because of the forward nature of the price setting decision, expectations of future inflation also appear. The parameter ω is the fraction of non-adjusting firms, and β is the discount factor.

Aggregate inflation is equal to

$$\pi_{t+1} = (1 - \omega)\bar{\pi}^*_{t+1}. \tag{4}$$

To keep the demand side of the model simple, let

$$x_{t+1} = \theta_t + e^v_{t+1}, \tag{5}$$

where θ is the central bank's instrument (or intended output gap) and e^v is a demand shock.

The model is completed with a specification of social loss and the policy regime. Social loss is assumed to take a quadratic form that depends on the costs arising from relative price dispersion and deviations of output from its welfare maximizing level. A central bank acting to minimize social loss chooses policy to minimize

$$L^{cb}_t = \left(\frac{1}{2}\right) E^{cb}_t \sum_{k=0}^{\infty} \beta^k \left[\pi^2_{t+k} + \lambda_z z^2_{t+k} + \lambda_x \left(x_{t+k} - e^u_{t+k}\right)^2\right], \tag{6}$$

where expectations are with respect to the central bank's information set (hence the superscript cb on the expectations operator). Equation (6) is a standard quadratic loss in inflation and output gap volatility with two modifications. First, the shock e^u reflects stochastic variation in the welfare gap between the flexible-price equilibrium level of output and the efficient level respectively. Second, the term z^2_{t+k} enters, where z^2 is the variance of prices across firms due to heterogeneous information and reflects the welfare costs associated with heterogeneous information. Recall that in the standard new Keynesian model with monopolistic competition and staggered price adjustment, inflation volatility generates an inefficient dispersion of relative prices across firms. Similarly, differences in information also causes relative prices to differ, and this is socially inefficient since the information heterogeneity is due to noise.

Finally, the policy regime is one of "constrained discretion" (King 2005) in the sense that I assume the decision to make announcements is one the central bank must commit to, but the choice of the policy instrument θ_t is make each period under discretion.

The basic timing is as follow:

1. At the end of period t, the central bank observes signals about $t+1$ shocks and sets its policy instrument θ_t.
2. Firms observe π_t, x_t, and θ_t as well as individual specific signals about $t+1$ shocks. Firms may also observe announcements made by the central bank.
3. Those firms that can adjust their price set prices for $t+1$.
4. Period $t+1$ actual shocks occur and π_{t+1} and x_{t+1} are realized.

3 Equilibrium with an opaque central bank

When the central bank is opaque, it makes no announcements. Private agents must base their inferences on what the central bank's outlook for the economy is from observing the current setting of the policy instrument. They forecast what other firms are expecting, as well as the output gap and the cost shock by combining their own private information with the information that can be gleaned from observing θ_t.

The model can be solved using the method of undetermined coefficients under the assumption of rational expectation. For details, see the appendix.

If $\Omega_{j,t+1}$ denotes the vector of signals observed by firm j, then the equilibrium strategy of a price-adjusting firm is a linear function of $\Omega_{j,t+1}$ and θ_t:

$$\pi^*_{j,t+1} = A\Omega_{j,t+1} + B\theta_t.$$

Aggregate inflation will equal

$$\pi_{t+1} = (1-\omega)\bar{\pi}^*_{t+1} = (1-\omega)\left(A\Omega_{t+1} + B\theta_t\right),$$

where $\Omega_{t+1} = \int \Omega_{j,t+1} dj$.

Let the 3×1 vector $E^j\Omega_\theta$ denote the impact observing θ_t has on firms' expectations of the aggregate information received by all firms and let $E^j Z_\theta$ denote the impact observing θ_t has on firms' expectations of the vector of fundamental shocks. If $\alpha = 1$ so that the measurement across firms is uncorrelated, $E^j\Omega_\theta = E^j Z_\theta$. The elasticity of inflation with respect to the instrument of monetary policy can be written as

$$\frac{\partial \pi_{t+1}}{\partial \theta_t} \equiv (1-\omega)B = \delta_1 + \delta_2,$$

where

$$\delta_1 = \frac{(1-\omega)(1-\omega\beta)\kappa}{\omega},$$

$$\delta_2 = \frac{(1-\omega)^2}{\omega} A E^j\Omega_\theta + \delta_1 D E^j Z_\theta,$$

and A and D are 1×3 vectors of coefficients (see the appendix). The parameter δ_1 is the elasticity of inflation with respect to the output gap in a standard new Keynesian model. It captures the direct effect of policy on inflation. The second term, δ_2, captures the informational effects of policy actions. This, in turn, consists of two components. The first captures the impact of θ on inflation arising from the adjustment of firms' expectations about the signals received by other firms (and so about the expectations of the other firms). The second captures the effect of θ on firms' expectations about the underlying shocks.

3.1 Optimal policy

I employ a calibrated version of the model to investigate the role informational asymmetries play in distorting policy responses. Standard parameter values are used; these are given in Table 1. The discount rate is set at 0.99, appropriate for quarterly data. Micro evidence on the Calvo parameter that governs the degree of nominal rigidity suggests a value of around 0.5, while time series macro estimates are generally much higher, closer to 0.8. I choose an intermediate value and set $\omega = 0.65$. The parameter κ is the sum of the coefficient of relative risk aversion and the inverse of the wage elasticity of labor supply. I set the first of these equal to 1 (log utility) and the second to 0.8, yielding $\kappa = 1.8$. Walsh (2007c) shows that $\lambda_z = (1-\omega)^2/\omega = 0.1885$. For the baseline case, I assume equal weight on inflation and output gap volatility in the loss function so that, expressed in terms of quarterly inflation rates, $\lambda_x = 1/16 = 0.0625$. Initially, I set the variances of all three shocks equal to 1.

Table 1: Parameter values

β	0.99
ω	0.65
κ	1.8
λ_z	0.1885
λ_x	0.0625

Tables 2a and 2b show the optimal policy responses to the central bank's forecast of each shock when policy is conducted under discretion in an opaque regime. The responses are shown for various combinations the quality of private sector information, measured by the signal to noise ratio γ_j, and γ_{cb}, measuring the quality of the central bank's information. Also shown under the column headed $\delta_1 + \delta_2$ is the elasticity of inflation with respect to the policy instrument θ. Table 2a is based on $\alpha = 0$, the case of common private information; Table 2b is based on $\alpha = 1$; the case of idiosyncratic private information. Row (1) of each table reports the optimal policy responses for the case of perfect information on the part of the private sector (a signal to noise ratio of one). In this case, there is no informational value in observing θ and $\delta_2 = 0$. Policy responses in this case are independent of the quality of the central bank's information, reflecting the certainty equivalence that Svensson and Woodford (2002) show holds in this case.

Table 2a: Optimal policy responses to shock forecasts: $\alpha = 0$

			$\sigma_s^2 = \sigma_v^2 = \sigma_u^2 = 1$			
	γ_{cb}	γ_j	$\delta_1 + \delta_2$	$E^{cb}e^s$	$E^{cb}e^v$	$E^{cb}e^u$
1)	–	1	0.3455	−0.3647	−1.0	0.3436
2)	0.4	0.4	0.1591	−0.1320	−0.9127	0.6750
3)		0.6	0.1951	−0.2088	−0.9568	0.5809
4)		0.8	0.2539	−0.2901	−0.9871	0.4649
5)	0.6	0.4	0.1442	−0.1227	−0.9132	0.6924
6)		0.6	0.1718	−0.1926	−0.9548	0.6082
7)		0.8	0.2281	−0.2750	−0.9855	0.4905
8)	0.8	0.4	0.1268	−0.1114	−0.9150	0.7146
9)		0.6	0.1410	−0.1688	−0.9533	0.6495
10)		0.8	0.1829	−0.2442	−0.9832	0.5436

Table 2b: Optimal policy responses to shock forecasts: $\alpha = 1$

	$\sigma_s^2 = \sigma_v^2 = \sigma_u^2 = 1$					
	γ_{cb}	γ_j	$\delta_1 + \delta_2$	e^s	e^v	e^u
1)	–	1	0.3455	−0.3647	−1.0	0.3436
2)	0.4	0.4	0.1474	−0.0975	−0.8877	0.7122
3)		0.6	0.2365	−0.1670	−0.9349	0.6244
4)		0.8	0.2277	−0.2585	−0.9773	0.5120
5)	0.6	0.4	0.1983	−0.0917	−0.8898	0.7247
6)		0.6	0.2212	−0.1539	−0.9342	0.8571
7)		0.8	0.2608	−0.2413	−0.9754	0.5410
8)	0.8	0.4	0.1865	−0.0853	−0.8922	0.7387
9)		0.6	0.2010	−0.1371	−0.9342	0.6873
10)		0.8	0.2319	−0.2114	−0.9725	0.5919

There are six key conclusions to draw from Tables 2a and 2b. First, as the quality of private sector information falls, the marginal impact of policy actions on inflation also declines, as shown in the column labeled $(1-\omega)B$. Second, a fall in the quality of central bank information increases the marginal impact of policy actions on inflation when $\alpha = 0$ but has ambiguous effects when $\alpha = 1$. Third, imperfect private and central bank information reduces the optimal policy response to a signal on the cost shock. This effect can be large. When $\gamma_{cb} = 0.8$ and $\gamma_j = 0.4$, the optimal response to e^s is -0.1114 when $\alpha = 0$ and -0.0853 when $\alpha = 1$, compared to -0.3647 in the $\gamma_j = 1$ case. Fourth, the central bank does not fully insulate the economy from demand shocks under imperfect information; the response to e^v is less than 1.0 in absolute value. Fifth, under imperfect information, the optimal response to welfare gap shocks is larger than when $\gamma_j = 1.0$. Sixth, the results are relative insensitive to variation in α.

Results two through five are a consequence of the first result, the reduced impact of policy on inflation. Because $\delta_1 + \delta_2$ is smaller with imperfect information, the central bank must accept greater output volatility to achieve any given degree of inflation volatility. This cause the optimal response to involve less inflation stabilization in the face of cost shocks. For the same reason, the inflation costs of responding to welfare gap shocks is lower, so the optimal response to welfare gap shocks rises.

Tables 2a and 2b were constructed under the assumption that the three fundamental shocks had equal variances. The basic conclusions from the table are robust to variations in the relative variances of the shocks. Altering the variance of welfare gap shocks has the biggest impact on the optimal response coefficients. This is illustrated in Tables 3a and 3b which are based on $\sigma_u^2 = 0.001$ while leaving the other two variances equal to one. The general conclusions from Tables 2a-b continue to hold for the parameterization of Tables 3a-b with one exception. With welfare gap shocks having a much smaller variance, the optimal response calls for a more than one-for-one response to expected demand shocks when private sector information is imperfect. When welfare gap shocks are very small, the model essentially has only two fundamental shocks – the cost shock and the aggregate demand shock. When the central bank adjusts θ to fully offset its forecast of the demand shock, part of the movement in the policy instrument is interpreted by the public as a reaction to a forecast of a cost shock. For example, suppose the central bank receives a positive signal e_{cb}^v. It lowers θ, but when private firms observe the cut in θ, they view this, in part, as evidence that the central bank is forecasting a positive cost shock. Firms therefore expect higher inflation. The central bank cuts θ more to help offset inflationary impact of this rise in expected inflation.

Table 3a: Optimal policy responses to shock forecasts: $\alpha = 0$

			$\sigma_s^2 = \sigma_v^2 = 1$, $\sigma_u^2 = 0.001$			
	γ_{cb}	γ_j	$\delta_1 + \delta_2$	$E^{cb}e^s$	$E^{cb}e^v$	$E^{cb}e^u$
1)	$-$	1	0.3455	-0.3647	-1.0	0.3436
2)	0.4	0.4	0.0905	-0.0934	-1.0085	0.8404
3)		0.6	0.1539	-0.1901	-1.0123	0.6702
4)		0.8	0.2375	-0.2869	-1.0081	0.4917
5)	0.6	0.4	0.0652	-0.0703	-1.0053	0.8787
6)		0.6	0.1187	-0.1589	-1.0095	0.7243
7)		0.8	0.2042	-0.2657	-1.0076	0.5294
8)	0.8	0.4	0.0353	-0.0403	-1.0019	0.9294
9)		0.6	0.0690	-0.1041	-1.0050	0.8177
10)		0.8	0.1415	-0.2152	-1.0061	0.6188

Table 3b: Optimal policy responses to shock forecasts: $\alpha = 1$

			$\sigma_s^2 = \sigma_v^2 = 1$, $\sigma_u^2 = 0.001$			
	γ_{cb}	γ_j	$\delta_1 + \delta_2$	$E^{cb}e^s$	$E^{cb}e^v$	$E^{cb}e^u$
1)	–	1	0.3455	−0.3647	−1.0	0.3436
2)	0.4	0.4	0.0655	−0.0551	−1.0048	0.9057
3)		0.6	0.1180	−0.1369	−1.0110	0.7647
4)		0.8	0.2024	−0.2509	−1.0104	0.5588
5)	0.6	0.4	0.0462	−0.0399	−1.0027	0.9309
6)		0.6	0.0873	−0.1078	−1.0077	0.8137
7)		0.8	0.1659	−0.2234	−1.0094	0.6072
8)	0.8	0.4	0.0244	−0.0218	−1.0009	0.9617
9)		0.6	0.0484	−0.0650	−1.0033	0.8863
10)		0.8	0.1056	−0.1659	−1.0063	0.7077

When private sector information is imperfect, Tables 2 and 3 show that the central bank will, in an opaque regime, respond less to its forecast of cost shocks and more to its forecast of welfare gap shocks than would be the case with perfect private sector information. Thus, again relative to the $\gamma_j = 1$ case, the welfare gap will be more stable and inflation less stable. By responding less to cost shock forecasts, output is made less volatile, but the cost shocks have a larger impact on inflation. By responding more to welfare gap shocks, these shocks have a smaller impact on the welfare gap, but the greater volatility of output leads to more inflation volatility. This result suggests that, when policy is opaque, requiring the central bank to increase its focus on inflation stabilization will move policy closer to the perfect information case.

4 The optimal weight on inflation objectives

In this section, I consider whether central banks should place more weight on stabilizing inflation than implied by social welfare. That is, should the central bank be held more accountable for achieving its inflation objectives when transparency is incomplete? While the results of the previous section suggested that assigning a larger weight to inflation would move policy closer to the outcomes under perfect private information, this does not necessarily mean that the net effect will be to increase welfare.

Suppose that the central bank is assigned the following loss function:

$$\left(\frac{1}{2}\right) E_t^{cb} \sum_{k=0}^{\infty} \beta^k \left[\pi_{t+k}^2 + \lambda_z z_{t+k}^2 + (1+\tau)\lambda_x \left(x_{t+k} - e_{t+k}^u\right)^2\right], \tag{7}$$

which differs from social loss as specified in (6) if $\tau \neq 0$. For $\tau < 0$, the central bank places less weight on output gap stabilization (more weight on inflation stabilization) than society does.[1] Rogoff (1985) showed that the optimal τ is less than zero when there is an average inflation bias under discretionary policy. Clarida, Galí, and Gertler (1999) showed that even in the absence of an inflation bias, the optimal τ is less than zero if cost shocks are positively serially correlated. In the present model, there is no average inflation bias and shocks are serially uncorrelated. The optimal τ may still differ from zero because of imperfect information and a lack of transparency.

Table 4 shows the optimal τ and the percent reduction in loss at the optimal τ for various combinations of central bank and private sector information. The top part of the table is constructed for the case of $\alpha = 0$ – all private sector information is common – while the bottom section shows the $\alpha = 1$ case – all private sector information is idiosyncratic. When private sector information is perfect ($\gamma_j = 1$), the optimal τ is equal to zero, regardless of the quality of the central bank's information. This is because policy

[1] The weight λ_z has been left unchanged as this arises from the the same distortions that cause inflation volitility to be costly. Thus, the focus here is on whether the central bank should place more or less weight on reducing the distortions created by relative price dispersion.

actions have no informational content in this case, so policy responses are not distorted.

Table 4: Optimal τ and percent reduction in loss

			$\sigma_s^2 = \sigma_v^2 = \sigma_u^2 = 1$			
	$\alpha = 0$			γ_j		
			0.4	0.6	0.8	1
1)		0.4	$-0.45(2.47\%)$	$-0.62(2.48\%)$	$-0.39(0.70\%)$	0
2)	γ_{cb}	0.6	$-0.31(3.08\%)$	$-0.65(5.64\%)$	$-0.45(2.03\%)$	0
3)		0.8	$-0.16(2.61\%)$	$-0.29(5.28\%)$	$-0.57(6.82\%)$	0
	$\alpha = 1$					
4)		0.4	$-0.34(1.71\%)$	$-0.63(3.25\%)$	$-0.49(1.31\%)$	0
5)	γ_{cb}	0.6	$-0.25(2.32\%)$	$-0.42(4.30\%)$	$-0.56(3.44\%)$	0
6)		0.8	$-0.16(2.51\%)$	$-0.19(3.33\%)$	$-0.56(9.01\%)$	0

In all cases, the optimal τ is negative, indicating that society is better off having the central bank place more weight on inflation stabilization relative to real objectives. Making the central bank more accountable for inflation stabilization mutes the distortions introduced by imperfect information. With $\tau < 0$ under discretion, the central bank will react more (in absolute value) to cost shocks, reducing their impact on inflation, and less to welfare gap shocks.

Table 5 repeats the calculations of Table 4 for the case of a small variance of the welfare gap shocks. This case corresponds to the more standard situation in which only demand and cost shocks are incorporated into the basic model. The optimal values for τ are larger (in absolute value) than those in Table 4, particularly when private information is poor. Comparing the policy responses to cost shocks in Tables 2a (when $\sigma_u^2 = 1$) and 3a (when $\sigma_u^2 = 0.001$) reveals that the central bank engages in less inflation stabilization when welfare gap shocks are small. Thus, the optimal τ rises, making the central bank more accountable for inflation stabilization.

Table 5: Optimal τ and percent reduction in loss

		$\sigma_s^2 = \sigma_v^2 = 1,\ \sigma_u^2 = 0.001$				
	$\alpha = 0$			γ_j		
			0.4	0.6	0.8	1
1)		0.4	$-0.77(2.47\%)$	$-0.65(1.47\%)$	$-0.40(0.32\%)$	0
2)	γ_{cb}	0.6	$-0.78(3.08\%)$	$-0.71(4.46\%)$	$-0.47(1.15\%)$	0
3)		0.8	$-0.84(2.61\%)$	$-0.80(15.15\%)$	$-0.62(6.37\%)$	0
	$\alpha = 1$					
4)		0.4	$-0.77(2.44\%)$	$-0.74(2.27\%)$	$-0.51(0.67\%)$	0
5)	γ_{cb}	0.6	$-0.81(4.96\%)$	$-0.78(6.06\%)$	$-0.58(2.28\%)$	0
6)		0.8	$-0.85(7.94\%)$	$-0.82(15.27\%)$	$-0.72(10.50\%)$	0

To conclude this section, in an opaque policy regime with asymmetric and imperfect information, the central bank should be structured to place more weight on inflation stabilization than society does, i.e., it should be held more accountable for achieving society's inflation objectives.

5 Transparency versus Opaqueness

The previous section showed that when policy lacks transparency, the central bank should be tasked to focus more weight on inflation stabilization (and less on welfare gap stabilization) than society does. Social welfare can be improved when the central bank's objective function is distorted relative to the social loss function. In this section, social loss under three regimes – opaque policy, opaque policy with an optimal τ, and transparent policy – are compared. While an opaque policy regime with an optimal τ clearly is always at least as good as an opaque policy that minimizes social loss, whether a transparent regime will dominant turns out to depend on the relative quality of the central bank's information.

Under a fully transparent regimes, the optimal τ is always zero – a transparency central bank should share society's preferences over inflation and real objectives. In that sense, transparency is a substitute for greater accountability based only on inflation outcomes.

To compare the three regimes, I report the percent difference in social loss between the two opaque regimes and the fully transparent regime. Thus, a positive value indicates the regime is dominated by transparency (loss is higher under the opaque regime) while a negative value indicates the opaque regime achieves a lower value of the loss function than is obtained under transparency. To focus on the role played by the central bank's information, I set the quality of private information γ_j^i equal to 0.6 for all of the shocks while varying γ_{cb}^s and γ_{cb}^v, with γ_{cb}^u fixed, first at 0.4 and then at 0.8. Because findings were similar for $\alpha = 0$ and $\alpha = 1$, only the latter results corresponding to the Morris-Shin heterogeneous information case are reported.

Table 6: Loss relative to transparency (%)

		$\alpha = 1$, $\gamma_j^i = 0.6$, $\sigma_i^2 = 1$, $i = s, v, u$					
		γ_{cb}^s					
		0.4		0.6		0.8	
		$\tau = 0$	$\tau = \tau^*$	$\tau = 0$	$\tau = \tau^*$	$\tau = 0$	$\tau = \tau^*$
$\gamma_{cb}^u = 0.4$							
	0.4	1.27	−2.02	0.96	−2.53	−0.10	−3.36
γ_{cb}^v	0.6	1.94	−2.01	1.71	−2.22	0.56	−3.22
	0.8	1.98	−1.89	1.97	−1.82	0.79	−2.85
$\gamma_{cb}^u = 0.8$							
	0.4	2.11	−2.29	1.79	−2.52	0.64	−3.27
γ_{cb}^v	0.6	5.58	−1.42	3.33	−1.52	2.10	−2.02
	0.8	4.91	0.58	4.97	0.81	3.67	0.40

In all but one case, transparency dominates the opaque policy when the central bank minimizes a loss function that corresponds to social loss. The one exception occurs when the central bank has very good information on the cost shock but poor information on the demand shock. Even in this case, however, outcomes under the two regimes are virtually the same. Since $\alpha = 1$ in Table 6, the environment corresponds to the Morris-Shin situation in which they have argued transparency might lower welfare by making expectations sensitive to central bank forecast errors.

When transparency is compared to an opaque regime in which the central bank is held to greater account for inflation outcomes, the advantage of transparency disappears. The excepts occur when the central bank has relatively good information on aggregate demand and welfare gap shocks, as shown in the last row of the table. Transparency allows the central bank to fully insulate both output and inflation from these shocks. If the potential gains from stabilizing the economy from demand shocks is large (because the central bank's forecast errors are small), then transparency is the dominate policy regime.

6 Conclusions

Only transparent central banks should maximize social welfare. In the face of asymmetric information about economic shocks, an opaque central bank should put more weight on achieving inflation objectives than society does. Holding the central bank to greater accountability for inflation stabilization helps offset the distortions introduced by asymmetric information. These distortions arise because the information conveyed by policy actions alters the incentives the central bank faces when setting optimal policy under discretion. To offset these distortions, the performance of a central bank that is not fully transparent should be weighed towards inflation stabilization. Thus, inflation targeting may be particularly relevant for central banks that are not transparent. A fully transparent central bank should maximize social welfare. Transparency removes the need to hold the central bank to greater accountability based on inflation outcomes. However, while it is inefficient to distort a transparent central bank's objectives by having it focus more on inflation, an opaque but conservative central bank may deliver better outcomes than a transparent central bank in a discretionary policy regime.

One argument for transparency is that it helps align private sector expectations with the central bank's projection for inflation. This role is absent in the present model, which might account for why the opaque regime with an optimal τ^* tends to produce better outcomes than a regime of full transparency. One way to introduce such a channel would be to allow for a stochastic target for inflation. Greater transparency might then allow the central bank to achieve better control of the inflation gap – inflation minus the target rate – by ensuring private sector expectations of inflation were more consistent with the central bank's assessment of the desired target rate of inflation.

References

[1] Amato, J. D. and H. S. Shin. 2003. "Public and Private Information in Monetary Policy Models."

[2] Baker, G., "Incentive Contracts and Performance Measures," *Journal of Political Economy*, 100, 1992, 598-614.

[3] Blinder, Alan S., "Monetary Policy Today: Sixteen Questions and about Twelve Answers," Banco de España Conference on *Central Banks in the 21st Century*, June 2006.

[4] Cornand, C. and F. Heinemann. 2004. "Optimal Degree of Public Information Dissemination." CESifo Working Paper No. 1353. December.

[5] Cukierman, Alex, "The Limits of Transparency," Dec. 2005.

[6] Cukierman, Alex, "Central Bank Independence and Monetary Policymaking Institutions: Past, Present, and Future," Central Bank of Chile, April 2006.

[7] Cukierman, Alex and Stefan Gerlach, "The Inflation Bias Revisited: Theory and Some International Evidence," *The Manchester School*, 71(5), Sept. 2003, 541-565.

[8] Cukierman, A. and A. H. Meltzer. 1986. "A Theory of Ambiguity, Credibility, and Inflation under Discretion and Asymmetric Information." *Econometrica*. 54 (September): 1099-1128.

[9] Dincer, N. N. and B. Eichengreen, "Central Bank Transparency: Where, Why, and with What Effects?" NBER Working Paper No. 13003, March 2007.

[10] Eijffinger, S. C. W. and P. M. Geraats. 2006. "How Transparent Are Central Banks?" *European Journal of Political Economy*. 22 (March): 1-21.

[11] Faust, J. and L. E. O. Svensson. 2002. "The Equilibrium Degree of Transparency and Control in Monetary Policy," *Journal of Money, Credit and Banking*. 34 (May): 520-539.

[12] Fukunaga, Ichiro, "Imperfect Comon Knowledge, Staggered Price Setting, and the Effects of Monetary Policy," *Journal of Money, Credit, and Banking*, 39(7), Oct. 2007, 1711-1739.

[13] Geraats, P. M. "Central Bank Transparency." 2002. *Economic Journal*. 112: 532-565.

[14] Geraats, P. M. 2005. "Transparency and Reputation: The Publication of Central Bank Forecasts," *Topics in Macroeconomics*. 5(1), 2005.

[15] Gosselin, P. A. Lotz, and C. Wyplosz, "Should Central Banks Reveal Expected Future Interest Rates?" Feb. 2007.

[16] Hellwig, C. 2002. "Public Announcements, Adjustment Delays and the Business Cycle." UCLA, November.

[17] Hellwig, C. 2004. "Heterogeneous Information and the Benefits of Transparency." UCLA, December.

[18] Jensen, H. 2002. "Optimal Degrees of Transparency in Monetary Policymaking." *Scandinavian. Journal of Economics*. 104(3): 399-422.

[19] King, M., "The Institutions of Monetary Policy," *American Economic Review*, 94 (2), May 2004, 1-13.

[20] Morris, S. and H. S. Shin. 2002."Social Value of Public Information." *American Economic Review*. 92 (December): 1521-1534.

[21] Poole, W., "Communicating the Fed's Policy Stance," HM Treasury/GES Conference *Is There a New Consensus in Macroeconomics?*, London, U.K., Nov. 30, 2005. (http://stlouisfed.org/new/speeches/2005/11_30_05.htm)

[22] Poole, W., "Fed Communications," St. Louis Forum, Feb. 24, 2006. (http://stlouisfed.org/new/speeches/2006/02_24_06.htm)

[23] Rudebusch, G. D. and J. C. Williams, "Revealing the Secrets of the temple: The Value of Publishing Central Bank Interest Rate Projections," Oct. 2006.

[24] Svensson, L. E. O. 2006. "Social Value of Public Information: Morris and Shin (2002) Is Actually Pro Transparency, Not Con." *American Economic Review*. 96 (March): 448-451.

[25] Svensson, L. E. O. and M. Woodford, "Optimal Policy with Partial Information in a Forward-Looking Model: Certainty-Equivalence Redux," 2002.

[26] Walsh, C. E., "Transparency, Flexibility, and Inflation Targeting." in Frederic Mishkin and Klaus Schmidt-Hebbel (editors). *Monetary Policy under Inflation Targeting*. Santiago, Chile: Banco Central de Chile, 2007a, 227-263.

[27] Walsh, C. E., "Optimal Economic Transparency, *International Journal of Central Banking*," March 2007b, 3(1), 5-36.

[28] Walsh, C. E., "Announcement and the Role of Policy Guidance," 32nd Annual Economic Policy Conference, Federal Reserve Bank of St. Louis, Oct. 18-19, 2007c.

[29] Woodford, M., *Money, Interest, and Prices*, Princeton: Princeton University Press, 2003a.

[30] Woodford, M., "Imperfect Common Knowledge and the Effects of Monetary Policy." in P. Aghion, R. Frydman, J. Stiglitz, and M. Woodford (eds.). *Knowledge, Information and Expectations in Modern Macroeconomics: In Honor of Edmund S. Phelps.* Princeton: Princeton University Press, 2003b.

[31] Woodford, M., "Central Bank Communications and Policy Effectiveness," Federal Reserve Bank of Kansas City Jackson Hole Symposium, *The Greenspan Era: Lessons for the Future*, 2005.

Appendix: Solving the basic model

Firm j's price setting strategy is given by

$$\begin{aligned}\pi^*_{j,t+1} &= (1-\omega)E^j_t\bar{\pi}^*_{t+1} + (1-\omega\beta)\left(\kappa E^j_t x_{t+1} + E^j_t e^s_{t+1}\right) \\ &\quad + \left(\frac{\omega\beta}{1-\omega}\right)E^j_t\pi_{t+2}. \qquad (8)\end{aligned}$$

In the absence of central bank announcements, firm $j's$ new information is given by

$$\begin{bmatrix} \Omega_{j,t+1} \\ \theta_t \end{bmatrix},$$

where $\Omega_{j,t+1}$ is the 3×1 vector of signals received by the firm. Assume firms' beliefs about monetary policy are given by

$$\theta_t = \gamma'\Gamma_{cb}\Omega_{cb,t+1},$$

where $\Omega_{cb,t+1}$ is the vector of the central bank's signals and Γ_{cb} is the diagonal matrix of the bank's signal to noise ratios. Let the 3×1 vector of fundamental shocks be denoted by Z_{t+1} and the aggregate signal across firms be Ω_{t+1}. Then one can write firm $j's$ expectation of Z_{t+1} as

$$E^j_t Z_{t+1} = \Theta^o_1\Omega_{j,t+1} + \Theta^o_2\theta_t$$

and

$$E^j\Omega_{t+1} = \Psi^o_1\Omega_{j,t+1} + \Theta^o_2\theta_t.$$

Firm $j's$ strategy will take the form

$$\pi^*_{j,t+1} = A\Omega_{j,t+1} + B\tilde{\theta}_t$$

In forming expectations about the pricing behavior of other firms adjusting in the current period, firm j's expectation of $\bar{\pi}^*_{t+1}$ is given by

$$\begin{aligned} E^j_t \bar{\pi}^*_{t+1} &= A E^j_{t+1} \Omega_{t+1} + B F \theta_t \\ &= A \left[\Psi^o_1 \Omega_{j,t+1} + \Psi^o_2 \tilde{\theta}_t \right] + B \theta_t \\ &= A \Psi^o_1 \Omega_{j,t+1} + \left(A \Psi^o_2 + B \right) \theta_t. \end{aligned}$$

Since

$$\pi_{t+1} = (1-\omega) \bar{\pi}^*_{t+1},$$

it follows that

$$\begin{aligned} E^j_t \pi_{t+2} &= (1-\omega) E^j_t \bar{\pi}^*_{t+2} \\ &= (1-\omega) E^j_t \left[A \Psi^o_1 \Omega_{j,t+2} + \left(A \Psi^o_2 + B \right) \theta_{t+1} \right] \\ &= 0. \end{aligned}$$

Defining ι_i as a 1×3 vector with a 1 in the i^{th} place and zeros elsewhere, we can write (8) for a price-adjusting firm's price change as

$$\begin{aligned} \pi^*_{j,t+1} &= (1-\omega) E^j_t \bar{\pi}^*_{t+1} + (1-\omega\beta)\kappa\theta_t \\ &\quad + (1-\omega\beta) \left(\iota_1 + \kappa \iota_2 \right) \left(\Theta^o_1 \Omega_{j,t+1} + \Theta^o_2 \theta_t \right) \\ &= (1-\omega) \left[A \Psi^o_1 \Omega_{j,t+1} + \left(A \Psi^o_2 + B \right) \theta_t \right] + (1-\omega\beta)\kappa\theta_t \\ &\quad + (1-\omega\beta) \left(\iota_1 + \kappa \iota_2 \right) \left(\Theta^o_1 \Omega_{j,t+1} + \Theta^o_2 \theta_t \right). \end{aligned}$$

Collecting terms,

$$\begin{aligned} \pi^*_{j,t+1} &= \left[(1-\omega) A \Psi^o_1 + (1-\omega\beta) \left(\iota_1 + \kappa \iota_2 \right) \Theta^o_1 \right] \Omega_{j,t+1} \\ &\quad + \left[(1-\omega\beta)\kappa + (1-\omega) \left(A \Psi^o_2 + B \right) + (1-\omega\beta) \left(\iota_1 + \kappa \iota_2 \right) \Theta^o_2 \right] \theta_t. \end{aligned}$$

Equating coefficients with the proposed solution yields

$$A = \left[(1-\omega\beta) \left(\iota_1 + \kappa \iota_2 \right) \right] \Theta^o_1 \left[I_4 - (1-\omega) \Psi^o_1 \right]^{-1},$$

and

$$B = \frac{(1-\omega\beta)\kappa}{\omega} + \left(\frac{1}{\omega}\right)\left[(1-\omega)A\Psi_2^o + (1-\omega\beta)\left(\iota_1 + \kappa\iota_2\right)\Theta_2^o\right].$$

Equilibrium inflation is given by

$$\pi_{t+1} = (1-\omega)\bar{\pi}_{t+1}^* = (1-\omega)\left(A\Omega_{t+1} + B\theta_t\right).$$

The impact of the policy instrument on inflation is $(1-\omega)B$. Letting $E^j\Omega_\theta = \Psi_2^o$, $E^jZ_\theta = \Theta_2^o$, and $D = (\iota_1/\kappa + \iota_2)$ yields the expression in the text.

The optimal policy under discretion involves minimizing

$$\left(\frac{1}{2}\right)E_t^{cb}\left[\pi_{t+1}^2 + (1+\tau)\lambda_x\left(x_{t+i} - e_{t+1}^u\right)^2\right]$$

The first order condition for the central bank decision problem under discretion is

$$(1-\omega)BE_t^{cb}\pi_{t+1} + (1+\tau)\lambda_x\left(\theta_t + E_t^{cb}e_{t+1}^v - E_t^{cb}e_{t+1}^u\right) = 0.$$

Using the fact that

$$\begin{aligned} E_t^{cb}\pi_{t+1} &= (1-\omega)AE_t^{cb}\Omega_{t+1} + (1-\omega)B\theta_t \\ &= (1-\omega)A\Gamma_{cb}\Omega_{cb,t+1} + (1-\omega)B\theta_t \end{aligned}$$

(since $E_t^{cb}\Omega_{t+1} = E_t^{cb}Z_{t+1} = \Gamma_{cb}\Omega_{cb,t+1}$), the first order condition becomes

$$\begin{aligned} 0 &= (1-\omega)B\left[(1-\omega)A\Gamma_{cb}\Omega_{cb,t+1} + (1-\omega)B\theta_t\right] \\ &\quad +(1+\tau)\lambda_x\left(\theta_t + E_t^{cb}e_{t+1}^v - E_t^{cb}e_{t+1}^u\right) \end{aligned}$$

This in turn implies that

$$\begin{aligned} \left[(1+\tau)\lambda_x + (1-\omega)^2B^2\right]\theta_t &= (1+\tau)\lambda_x\iota_3\Gamma_{cb}\Omega_{cb,t+1} \\ &\quad -(1+\tau)\lambda_x\iota_2\Gamma_{cb}\Omega_{cb,t+1} \\ &\quad -(1-\omega)^2BA\Gamma_{cb}\Omega_{cb,t+1}, \end{aligned}$$

so in terms of the individual coefficients,

$$\gamma_1 = -\left[\frac{(1-\omega)^2 B A_1}{(1+\tau)\lambda_x + (1-\omega)^2 B^2}\right] \tag{9}$$

$$\gamma_2 = -\left[\frac{(1+\tau)\lambda_x + (1-\omega)^2 B A_2}{(1+\tau)\lambda_x + (1-\omega)^2 B^2}\right] \tag{10}$$

$$\gamma_3 = \left[\frac{(1+\tau)\lambda_x - (1-\omega)^2 B A_3}{(1+\tau)\lambda_x + (1-\omega)^2 B^2}\right], \tag{11}$$

The following steps are involved in solving the model:

1. Start with guesses for δ.
2. Form Θ and Ψ.
3. Calculate A, and B.
4. Calculate new values for δ.
5. Iterate until the process converges.

Transparency: Under transparency, firms observe their own Ω_j as well as Ω_{cb}. Thus,

$$E^j Z_{t+1} = \Theta^f \begin{bmatrix} \Omega_j \\ \Omega_{cb} \end{bmatrix} \text{ and } E^j \Omega = \Psi^f \begin{bmatrix} \Omega_j \\ \Omega_{cb} \end{bmatrix}.$$

Firm $j's$ strategy takes the form

$$\pi^*_{j,t+1} = A\Omega_{j,t+1} + K\Omega_{cb,t+1} + B\theta_t$$

We can write a price-adjusting firm's price change as

$$\begin{aligned}
\pi^*_{j,t+1} &= (1-\omega)E^j_t\bar{\pi}^*_{t+1} + (1-\omega\beta)\kappa\theta_t + (1-\omega\beta)\left(\iota_1+\kappa\iota_2\right)E^j_tZ_{t+1} \\
&\quad + \left(\frac{\omega\beta}{1-\omega}\right)E^j_t\pi_{t+2} \\
&= (1-\omega)E^j_t\bar{\pi}^*_{t+1} + (1-\omega\beta)\kappa\theta_t \\
&\quad + (1-\omega\beta)\left(\iota_1+\kappa\iota_2\right)\left(\Theta^f_1\Omega_{j,t+1}+\Theta^f_2\Omega_{cb,t+1}\right) + \left(\frac{\omega\beta}{1-\omega}\right)E^j_t\pi_{t+2}.
\end{aligned}$$

Following the same steps as employed to solve for the equilibrium under the opaque regime, one obtains

$$A = \left[(1-\omega\beta)\left(\iota_1+\kappa\iota_2\right)\right]\Theta^f_1\left[I_4-(1-\omega)\Psi^f_1\right]^{-1},$$

$$K = \left(\frac{1}{\omega}\right)\left[(1-\omega)C\Psi^f_2 + (1-\omega\beta)\left(\iota_1+\kappa\iota_2\right)\Theta^f_2\right] + \beta A\Theta^f_2,$$

and

$$B = \frac{(1-\omega\beta)\kappa}{\omega}.$$

Equilibrium inflation is then

$$\pi_{t+1} = (1-\omega)\bar{\pi}^*_{t+1} = (1-\omega)\left(A\Omega_{t+1}+K\Omega_{cb,t+1}+B\theta_t\right).$$

Optimal policy under discretion involves minimizing

$$\left(\frac{1}{2}\right)E^{cb}_t\left[\pi^2_{t+1}+(1+\tau)\lambda_x\left(x_{t+i}-e^u_{t+1}\right)^2\right]$$

The first order condition for the central bank decision problem under discretion is

$$(1-\omega)BE^{cb}_t\pi_{t+1} + (1+\tau)\lambda_x\left(\theta_t+E^{cb}_te^v_{t+1}-E^{cb}_te^u_{t+1}\right) = 0.$$

Since

$$
\begin{aligned}
E_t^{cb}\pi_{t+1} &= (1-\omega)AE_t^{cb}\Omega_{t+1} + (1-\omega)K\Omega_{cb,t+1} + (1-\omega)B\theta_t \\
&= (1-\omega)\left(A\Gamma_{cb} + K\right)\Omega_{cb,t+1} + (1-\omega)B\theta_t,
\end{aligned}
$$

the first order condition becomes

$$
\begin{aligned}
0 &= (1-\omega)B\left[(1-\omega)\left(A\Gamma_{cb} + K\right)\Omega_{cb,t+1} + (1-\omega)B\theta_t\right] \\
&\quad -(1-\omega)BE_t^{cb}e_{t+1}^{p} + (1+\tau)\lambda_x\left(\theta_t + E_t^{cb}e_{t+1}^{v} - E_t^{cb}e_{t+1}^{u}\right)
\end{aligned}
$$

This in turn implies that

$$
\begin{aligned}
\left[(1+\tau)\lambda_x + (1-\omega)^2B^2\right]\theta_t &= (1+\tau)\lambda_x\iota_3\Gamma_{cb}\Omega_{cb,t+1} \\
&\quad -(1+\tau)\lambda_x\iota_2\Gamma_{cb}\Omega_{cb,t+1} \\
&\quad +(1-\omega)B\iota_4\Gamma_{cb}\Omega_{cb,t+1} \\
&\quad -(1-\omega)^2B\left(A + K\Gamma_{cb}^{-1}\right)\Gamma_{cb}\Omega_{cb,t+1},
\end{aligned}
$$

so the individual coefficients in the policy rule are

$$
\gamma_1 = -\left[\frac{(1-\omega)^2B\left(A_1 + K_1/\gamma_{cb}^{s}\right)}{(1+\tau)\lambda_x + (1-\omega)^2B^2}\right] \tag{12}
$$

$$
\gamma_2 = -\left[\frac{(1+\tau)\lambda_x + (1-\omega)^2B\left(A_2 + K_2/\gamma_{cb}^{v}\right)}{(1+\tau)\lambda_x + (1-\omega)^2B^2}\right] \tag{13}
$$

$$
\gamma_3 = \left[\frac{(1+\tau)\lambda_x - (1-\omega)^2B\left(A_3 + K_3/\gamma_{cb}^{u}\right)}{(1+\tau)\lambda_x + (1-\omega)^2B^2}\right], \tag{14}
$$