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Endogenous Policy Announcement and Accountability for Inflation Target

Keiichi Morimoto

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GCOE Secretariat
Graduate School of Economics
OSAKA UNIVERSITY
1-7 Machikaneyama, Toyonaka, Osaka, 560-0043, Japan

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Abstract

In this paper, I show that accountability for inflation target will improve social welfare when the central bank makes transparency-opaqueness choices endogenously. The key elements are uncertainty of the firms' informational quality, the opacity bias of constrained discretionay monetary policy under noisy information, and the role of harmful noisy public information. Based on the qualitative and quantitative result, I present a policy recommendation as to policy announcements and inflation targeting regime.

JEL Classification: D82, E52, E58

Keywords: asymmetric information, economic transparency, inflation targeting

*Graduate School of Economics, Osaka University, 1-7, Machikaneyama, Toyonaka,Osaka 560-0043, Japan. (E-mail address: gge014mk@mail2.econ.osaka-u.ac.jp) I am grateful to Takushi Kurozumi and all participants of Macroeconomics Conference for Young Professionals, Osaka (February 8, 2009). Remaining errors are my own.

1 Introduction

In recent years, the role of information in monetary policy analysis has been one of the most important issues in monetary economics. The problems about the ambiguous effects of transparency on social welfare have been focused. For example, see Morris and Shin (2002).

In this paper, I show that accountability for inflation target will improve social welfare when the central bank makes the transparent-opaqueness choice endogenously. Among the five kind of transparency classified by Geraats (2002), I focus on economic transparency. I explore the relationship between the central bank's announcement under noisy information and social welfare, how the central bank decides to make policy announcements and the design of the mechanism to implement the announcement actions.

The problem of endogenous regime choice by the central bank has not been argured yet. In the literature, using a traditional Phillips curve, Faust and Svensson (2002) analyze endogenous (continuous) choice of degree of control and transparency under both commitment and discretion. They emphasizes the importance of commitment mechanisms and policy objectives in treating central bank transparency. The meaning of transparency in the model of Faust and Svensson (2002) is not a provision of the central bank's forecast of future economic developmets.

In the model of this paper, transparency means that the central bank gives announcements on its outlook for future economic shocks. Opaqueness means that the central bank makes no announcements on its information. Since whether the central bank announce its information to the public can be thought as a classification criterion of monetary policy regimes, the decision-makings about transparecy or opaqueness is a kind of monetary policy regime choices. Another feature of my analysis is that the central bank's choice is discrete. There are only two alternatives, transparency and opaqueness. This generates difficulty of the central bank's approapriate decision-making because failure in judgement generated by imperfect information would tend to bring larger losses than in continuous choice cases. I treats the problem in this paper.

Section 2 describes the basic model with exogenous policy announcement. Section 3 quickly reviews the basic model's welfare implications which is necessary to understand the main result of this paper. Section 4 presents the main result of the relationship between the endogenous policy announcements and accountability for inflation target. Section 5 concludes.

2 The Model

I use the model of Walsh (2007b) and Walsh (2008). I abstract from Morris and Shin's (2002) informational heterogeneity of firms in the base model since that is not an important assumption for the main result of this paper.

There are a continuum of monopolistic competitive firms. Their price-setting behavior is characterized by Calvo-type staggered pricing, which introduces nominal rigidity to the model. Each firm and the central bank receive private signals on the fundamental shocks. I assume that each firm's signal is identical, so that, there is informational asymmetry only between the private sector and the central bank.

2.1 Timing and Infomational Structure

In the model economy there are the three fundamental shocks; cost, demand and welfare gap shocks, denoted by u, v, w respectively. I assume that the central bank's policy instrument is the intended next-period output gap.

The timing is as follows:

1. To begin with, the central bank chooses between the transparent regime and the opaque regime. The transparent (opaque) regime is one in which the central bank makes (no) announcements on its forecast of future economic shocks. The difference of the model of this paper and Walsh (2008) is this dicision-making of the central bank.

2. At the end of period $t-1$, the central bank receives its signals on the shocks in period t and sets the value of its policy instrument.

3. The private sector receives the signals on the shocks in period t and the value of policy instrument the central bank set.

4. The firms which can adjust their price set prices in period t.

5. At the beginning of period t, the three shocks are realized and then the inflation rate and output gap in period t are determined.

At the end of period $t-1$, each firm receives the signals, u_t^f, v_t^f, w_t^f, on the shocks in period t in the following form.

$$
\begin{aligned}
u_t^f &= u_t + \varepsilon_{u,t}^f, \\
v_t^f &= v_t + \varepsilon_{v,t}^f, \\
w_t^f &= w_t + \varepsilon_{w,t}^f,
\end{aligned}
$$

where u_t, v_t and w_t are the realization of the shocks in period t, and $\varepsilon_{u,t}^f$ and $\varepsilon_{v,t}^f$ are the firms' measurement errors.

In the same way, the central bank receives signals on the three shocks by

$$
\begin{aligned}
u_t^{cb} &= u_t + \varepsilon_{u,t}^{cb}, \quad (1) \\
v_t^{cb} &= v_t + \varepsilon_{v,t}^{cb}, \quad (2) \\
w_t^{cb} &= w_t + \varepsilon_{w,t}^{cb}. \quad (3)
\end{aligned}
$$

I assume that all shocks and measurement errors are independent and serially uncorrelated and follow the normal distribution with mean zero.

The key elements of the informational structure are

$$
\gamma_s^f = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_{f,s}^2}, \; \gamma_s^{cb} = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_{cb,s}^2} \; (s = u, v, w),
$$

where σ_s^2 is the variace of shock s_t and $\sigma_{f,s}^2$ and $\sigma_{cb,s}^2$ are the variance of $\varepsilon_{s,t}^f$ and $\varepsilon_{s,t}^{cb}$ respectively. The noise ratios above are the measure of quality of the firms' and the central bank's information on the future economic shocks. For example, when γ_u^{cb} is high, the central bank has precise outlook for future cost shock. If $\gamma_s^{cb} = 1$, then the central bank's information on shock s is perfect and if $\gamma_s^{cb} < 1$, then it is imperfect.

In the line of rational expectations, I assume that the private sector knows γ_s^{cb} ($s = u, v, w$). Thus, since the central bank's forecast of the shock s is given by (see (1),(2),(3))[1]

$$E_{t-1}^{cb} s_t = \gamma_s^{cb} s_t^{cb} \ ,$$

the private sector is able to observe the central bank's forcasts if the central bank reveals its signals. Therefore, the transparent regime of monetary policy is one in which the central bank announces its signals to the private sector.

2.2 Supply and Demand Sides

As in Walsh (2007a), by the standard assumption of Calvo-pricing and monopolistic competition, the AS relation (supply side) of the model is represented by the following New-Keynesian Phillips curve:

$$\pi_t = \beta E_{t-1}^f \pi_{t+1} + \frac{(1-\omega)(1-\beta\omega)}{\omega}(\kappa E_{t-1}^f x_t + E_{t-1}^f u_t), \tag{4}$$

where π_t and x_t are inflation rate and output gap in period t and the parameter β, ω and κ represents the discount factor, the probability which each firm can not adjust its price and the elasticity of inflation with respect to output gap respectively. For details, see Appendix.

I specify the AD relation (demand side) by

$$x_t = \theta_{t-1} + v_t, \tag{5}$$

where θ_{t-1} is the central bank's policy instrument in period $t-1$ (the intended output gap).

2.3 Monetary Policy Objectives

To measure social welfare, I adopt the standard social loss function such that

$$L = \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t [\pi_t^2 + \lambda (x_t - w_t)^2], \tag{6}$$

[1] $E_{t-1}^{cb} s_t$ means the expectation of shock s_t based on the centrtal bank's information in period $t-1$.

where the parameter λ represents the social preference relation between inflation and output gap.

When the monetary policy regime is inflation targeting, the central bank is accountable for the inflation target to some extent. Thus, as in Walsh (2003), I set the loss function of the central banker to

$$L^{cb} = \frac{1}{2} E_0^{cb} \sum_{t=0}^{\infty} \beta^t \Big[\pi_t^2 + \lambda (x_t - w_t)^2 + \tau (\pi_t - \pi^T)^2\Big], \tag{7}$$

where π^T is the (non-state-contingent) target value of inflation rate and the parameter $\tau \geq 0$ is the degree of accountability for the target. Since there is no average inflation bias in this model, the appropriate inflation target is zero. Hence, by (5), the central bank's loss function is reduced to

$$L^{cb} = \frac{1}{2} E_0^{cb} \sum_{t=0}^{\infty} \beta^t \Big[(1+\tau)\pi_t^2 + \lambda (x_t - w_t)^2\Big]. \tag{8}$$

3 Opaque and Transparent Regimes

The qualitative welfare implication of the opaque and transparent monetary policy is similar to Walsh (2008) but I quickly review them for convienience to understand the background of the results in the next section.

3.1 Opaque Regime and Optimal Degree of Accountability

In opaque regimes, the central bank does not announce the signals it receives, $\Omega_t^{cb} = [u_t^{cb}, v_t^{cb}, w_t^{cb}]'$. Thus, the private sector will set their optimal prices by infering the central bank's information Ω_t^{cb} through the revealed value of the policy instrument θ_{t-1}.

Let $\Omega_t^f = [u_t^f, v_t^f, w_t^f]'$. Then, each firm's information vector in period $t-1$ is $[\Omega_t^f, \theta_{t-1}]'$. By using the method of minimal state variables, the equilibrium pricing strategy will be of the form such as

$$\pi_t^* = A^o \Omega_t^f + B^o \theta_{t-1}, \tag{9}$$

Table 1: Optimal Policy Responses in the opaque regime ($\sigma_u^2 = \sigma_v^2 = \sigma_w^2 = 1$)

γ_s^{cb}	γ_s^f	π_θ	$E^{cb}u$	$E^{cb}v$	$E^{cb}w$
$*$	1	0.474	-0.452	-1.000	0.3634
0.4	0.4	0.122	-0.126	-1.017	0.8621
	0.8	0.265	-0.301	-1.024	0.5022
0.8	0.4	0.043	-0.058	-1.006	0.9421
	0.8	0.162	-0.279	-1.011	0.6439

where A^o is 1 × 3 and B^o is 1 × 1.[2] Aggregate inflation rate is

$$\pi_t = (1-\omega)\pi_t^* = (1-\omega)(A^o\Omega_t^f + B^o\theta_{t-1}).$$

The reponse of the inflation rate to the policy instrument is

$$\pi_\theta \equiv \frac{\partial \pi_t}{\partial \theta_{t-1}} = \frac{(1-\omega)(1-\beta\omega)}{\omega}\kappa(1 + C^o E^f S_\theta),$$

where C^o is 1 × 3 and $E^f S_\theta$ is impact which observing θ_{t-1} has on firms' expectation of the vector of fundamental shocks, $S_t \equiv [u_t, v_t, w_t]'$. [3] The first and second term in the bracketed part of the right-hand side of (12) are the direct effect and the informational effect on inflation. Note that if π_θ is high, then given a degree of inflation volatility, the central bank can make output gap volatility small.

In the following analysis, I specify the value of parameters. [4] The baseline values of parameters are as follow: $\beta = 0.99$, $\omega = 0.75$, $\kappa = 1.8$, $\lambda = 0.0625$, $\sigma_u^2 = \sigma_v^2 = 1$. I set $\sigma_w^2 = 0.001$ to make the model close to the standard model in which there are no welfare gap shocks.

The key findings in Table 1 are the next two points. First, given γ_s^{cb}, π_θ is increasing in γ_s^f. In the opaque regime, under imperfect information ($\gamma_s^f < 1$), θ conveys information

[2] $\pi_t^* = p_t^* - p_{t-1}$. p_t^* is the optimal price of each firm which can adjust their prices and p_t is aggregate (log) price level.

[3] The concrete definition of $E^f S_\theta$ lies in the appendix.

[4] These values are consistent with standard New Keynesian models. See Walsh (2008).

Table 2: Optimal Accountability in the opaque regime = τ_o^*($\sigma_u^2 = \sigma_v^2 = \sigma_w^2 = 1$)

γ_s^{cb}	γ_s^f	τ_o^*
0.4	0.4	3.34
	0.6	1.86
	0.8	0.67
	1	0
0.8	0.4	4.76
	0.6	3.98
	0.8	1.63
	1	0

on the central bank's forecast to the private sector. A rise in θ lowers the firms' forecasts of demand shocks and also reduces their forcasts of cost shocks, so that the expected inflation decreases. Second, imperfect information reduces the optimal policy responses to the central bank's signals on the cost and demand shock. This is the immediate result of the first point.

The second point above suggests that positive degree of accountability for inflation target is optimal. The reason is that it makes the central bank stabilize inflation volatility in the face of cost shocks and this means monetary policy is closer to the perfect information case. In fact, Table 2 supports such a conjecture. Note that given the quality of the central bank's information, the optimal degree decreases with the quality of the private sector's information. A rise in γ_s^f reduces inefficient informational effect which the policy instrument makes. Note also that in the perfect information case, there is no inefficient informational effect and so the optimal degree of accountability is zero.

3.2 Transparent Regime

In a transparent regime, the central bank announces its signals on the fundamental shocks. Thus, the information vector of the firms in period $t-1$ is $[\Omega_t^f, \Omega_t^{cb}, \theta_{t-1}]$. Hence, the firms' equilibrium pricing strategy is of the form such as

$$\pi_t^* = A^t \Omega_t^f + D^t \Omega_t^{cb} + B^t \theta_{t-1},$$

A^t and D^t are 1×3 and B^t is 1×1. As shown in Appendix,

$$\pi_\theta = \frac{\partial \pi_t}{\partial \theta_{t-1}} = \frac{(1-\omega)(1-\beta\omega)}{\omega}\kappa,$$

which suggests that there is no informational effect of the policy instrument in the transparent regime. Therefore, the optimal degree of accountability for inflation target is zero whatever the values of noise ratios are. That is, Rogoff's (1985) conservative central banker reduces social loss under imperfect information. In this model, the cost shocks are serially uncorrelated. Hence, without any infomation effect, there is no reason to consider the positive degree of accountability. See Clarida et al.(1999)

3.3 Transparency versus Opaqueness

Figure 1 presents welfare comparison between the transparent and opaque regime with the optimal degree of accountability. The key parameters are γ_u^{cb} and γ_s^f. The intuition is clear. If γ^f is large, then the quality of the central bank's information on demand shock is high. Thus, the central bank can set the policy instrument and the gain of transparency dominates that of opaqueness.

4 Endogenous Policy Announcement and Accountability

This section is the main body of the paper. In the last section, it is exogenous whether the central bank announces its forecast for the future economic development. In this section, I will endogenize the central bank's choice between the transparent and opaque regime. I call it transparent-opaqueness choice. Since I assume that the monetary policy regime is constrained discretion, the central bank have to make transparency-opaqueness choices before it actually conducts monetary policy and commits it through the future. [5]

[5] See King (2002).

The simulation result of the last section suggests that a key element to determine which of transparent and opaque regime is desirable is the quality of the firm's information, γ_s^f.

4.1 Endogenous Policy Announcement

I add the following assumptions. The central bank chooses whether to announce to the public its information of the future economic development. Before the decision-making above, the central bank receives signal $\tilde{\gamma}_s^f$ on γ_s^f. The signal $\tilde{\gamma}_s^f$ is assumed to be uniformly distributed on the interval $[\gamma_s^f - a_s, \gamma_s^f + a_s]$, where a_s is a positive parameter. It considers both the opaque and transparent regimes. About the opaque regime, given a degree τ of the accountability for inflation target, it anticipates the coefficients A, B of the private sector's response such that

$$\pi_t = (1-\omega)(A\Omega_t^f + B\theta_{t-1}),$$

its own response coefficient Θ such that $\theta_{t-1} = \Theta\Gamma^{cb}\Omega_t^{cb}$ and equilibrium dynamics of the model economy, and then estimates expected value of its loss function L^{cb} in the opaque regime. The case of the transparent regime is analogously calculated. [6]The transparent regime is chosen if the expected value is smaller in transparent regime than in the opaque regime.

With large measurement error of the quality of the firms' information, $|\gamma_s^f - \tilde{\gamma}_s^f|$, the central bank might make a mistake on TOCs and leads catastrophic social loss. Since results of transparency-opaqueness choices crucially depend on the degree of accountability for the inflation target, I explore the role of accountability for beneficial implementation of transparency-opaqueness choices. In general, if τ is small, then the central bank will be tend to choice transparent regime. However, this does not necessarily improve social welfare since the opaque regime is desirable when γ_s^f is low. Thus, there is room to optimize the expected social welfare with respect to τ with the quality of the firms' information given.

[6]In the transparent regime, the private sector's response is of the form such as $\pi_t = (1-\omega)(A\Omega_t^f + D\Omega_t^{cb} + B\theta_{t-1})$.

I formulate this problem. Before the beginning of the period 0, the central bank receive the signal

$$\tilde{\gamma}_s^f \sim U([\gamma_s^f - a_s, \gamma_s^f + a_s]),\ s = u, v, w.$$

The central bank chooses between the transparent and opaque regime to minimize its loss function subject to that it must subsequently conduct monetary policy under the constrained discretionary regime it chooses. That is, the behavior of the central bank is

$$\min_{i \in \{0,1\}} \quad \frac{1}{2} E_0^{cb} \sum_{t=0}^{\infty} \beta^t \Big[(1+\tau)\pi_t^2(i,\tau) + \lambda(x_t(i,\tau) - w_t)^2\Big],$$

where 0 and 1 indicate the transparent and opaque regime respectively and $\{\pi_t(i,\tau), x_t(i,\tau)\}_{t=0}^{\infty}$ is equilibrium dynamics of the model when the degree of accountability for the inflation target is τ and the central bank chooses regime i. Because the central bank chooses either transparent regime or opaque regime, the choice can be represented by a function

$$C : (\tilde{\gamma}_u^f, \tilde{\gamma}_v^f, \tilde{\gamma}_w^f, \tau) \mapsto \{0, 1\},$$

Once the central bank makes a transparency-opaqueness choice, the monetary policy regime is determined and optimal monetary policy is conducted under the regime. Eventually, given the actual firms' infomational quality, the social loss L depends on the result of the transparency-opaqueness choice, which is given by a function

$$L(\ \cdot\ |\gamma_u^f, \gamma_v^f, \gamma_w^f) : \{0, 1\} \to \mathbb{R}.$$

Thus, the optimal degree τ^{**} of accountability for inflation target is written by

$$\tau^{**}(\gamma_u^f, \gamma_v^f, \gamma_w^f) \in \underset{\tau \geq 0}{\operatorname{argmin}}\, E\Big[L\Big(C(\tilde{\gamma}_u^f, \tilde{\gamma}_v^f, \tilde{\gamma}_w^f, \tau)\Big|\gamma_u^f, \gamma_v^f, \gamma_w^f\Big)\Big],$$

where $\tilde{\gamma}_s^f \sim U([\gamma_s^f - a_s, \gamma_s^f + a_s]),\ s = u, v, w.$

For simplicity, I consider the case where $\gamma_u^f = \gamma_v^f = \gamma_w^f (= \gamma^f)$ and $a_u = a_v = a_w (= a)$. Hence, the expectations will be taken with repect to $\tilde{\gamma}^f \sim U([\gamma^f - a, \gamma^f + a])$. For numerical calculation, I set the baseline values such that $a = 0.2$, $\gamma_u^{cb} = \gamma_v^{cb} = \gamma_w^{cb} = 0.8$.

Figure 2 shows the simulation result. It is intuitively plausible. When the firms' informational noise is strong ($\gamma^f \leq \gamma_0$), τ^{**} is identical to τ^*, the optimal degree of accountability without parameter uncertainty for the central bank. In this case, τ^* is large and so the central bank will definitely choose the opaque regime if the optimal accountability τ^* is assigned since monetary policy under transparent regime is intensely distorted by strong accountability τ^*. [7]

When $\gamma_0 < \gamma^f < \gamma_1$, $\tau^{**} > \tau^*$. Since τ^* is somewhat small, under τ^*, there is possibility that the central bank chooses the transparent regime. The quality of the private sector's information is not high, so that the private sector's response to noise of the central bank information is sensitive. Accountability for inflation target helps to make the cetnral bank choose the transparent regime. Intuitively, it is optimal to escape loss of inflation volatility under the transparent regime stochastically by imposing strong accountability for inflation target on the central bank when it might fail in transparency-opaqueness choices since announcing inaccurate information generates crucial social loss.

When $\gamma^f > \gamma_1$, $\tau^{**} = \tau^*$ again. Since $\tau = 0$ brings large opacity bias under opaque regime, assigning it makes the central bank choose the transparent regime definitely.

To summerize, the policy implication of the analysis above is:

Result 1

Assume that welfare gap shocks are very small (i.e. $\sigma_w \approx 0$). If the central bank makes transparency-opaqueness choices and there is uncertfuture economic developments, then it is optimal to impose higher (or equal) degaincy about the central bank's information on the quality of firms' outlook for ree of accountability for inflation target on the central banker than in the case of certainty.

By Figure 1, the optimal degree of accountability for inflation target jumps at γ_1, which is the threshold of welfare comparison between transparency and opaqueness under certainty about the firms' informational quality. This is a difficulty of the suboptimal implementation of transparency-opaqueness choices. Discreteness of announcement policy regimes generate the problem.

[7] Note that the optimal degree of accountability under transparent regime is 0 independent of noise ratios γ.

5 Conclusion

Transparency does not necessarily improve social welfare. This fact plays a significant role in the design of an optimal monetary policy regime. In this paper, I show that accountability for the inflation target can exclude harmful central bank transparency which confuses the private sector.

There are two remaining problems. First, another process of the central bank's transparency-opaqueness choices should be considered. In the model, the central bank is assumed to make transparency-opaqueness choices according only to its anticipation of the private sector's response. Second, the central bank makes transparency-opaqueness choices when it conducts commitment policy. Under commitment, the opacity bias will disappear but the loss generated from noisy central bank's informaiton will not and so it is meaningful to investigate how to implement the suboptimal transparency-opaqueness choices.

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Appendix

Derivation of the New Keynesian Phillips curve

In the standard assumption of the Calvo-pricing, firm j's price adjustment strategy is

$$p^*_{j,t} = (1-\beta\omega)\sum_{s=0}^{\infty}(\beta\omega)^s\Big(E^j_{t-1}MC_{t+s} + E^j_{t-1}p_{t+s} + E^j_{t-1}u^j_{t+s}\Big),$$

where MC_{t+s} denotes nominal marginal cost in period $t+s$. By this equation, we obtain

$$p^*_{j,t} = (1-\beta\omega)\Big(E^j_{t-1}p_t + E^j_{t-1}MC_t + E^j_{t-1}u_t\Big) + \beta\omega E^j_{t-1}p^*_{j,t+1}. \tag{10}$$

Aggregate price level in period t is given by

$$p_t = (1-\omega)p^*_t + \omega p_{t-1},$$

which implies

$$\pi_t = p_t - p_{t-1} = \frac{1-\omega}{\omega}(p^*_t - p_t), \tag{11}$$

where p^*_t is the average of $p^*_{j,t}$ over price-adjusting firm j. Since all firms are symmetric in this model, $p^*_{j,t} = p^*_t$. Assuming $MC_t = \kappa x_t$, from (17) and (18),

$$\pi^*_t = \frac{1-\beta\omega}{\omega}\kappa E^f_{t-1}x_t + \frac{1-\beta\omega}{\omega}E^f_{t-1}u_t + \frac{\beta}{1-\omega}E^f_{t-1}\pi_{t+1}. \tag{12}$$

Hence, from (17) and (19), I obtain the New Keynesian Phillips curve.

Solving the Model under Opaque Regime

Assume that the private sector's belief about monetary policy is

$$\theta_{t-1} = \Theta^o\Gamma^{cb}\Omega^{cb}_t, \tag{13}$$

where Θ is 1×3 undetermined coefficient and

$$\Gamma^{cb} = \begin{pmatrix} \gamma^{cb}_u & 0 & 0 \\ 0 & \gamma^{cb}_v & 0 \\ 0 & 0 & \gamma^{cb}_w \end{pmatrix}.$$

The private sector's expectation of the aggregate shock vector $S_t = (u_t, v_t, w_t)$ and the firms price-adjustment strategy are of the forms such as

$$E^f_{t-1} S_t = \Psi^0_1 \Omega^f_t + \Psi^o_2 \theta_{t-1}, \tag{14}$$

$$\pi^*_t = A^o \Omega^f_t + B^o \theta_{t-1}. \tag{15}$$

Since $E^f_{t-1}\pi_{t+1} = 0$ by $\pi_t = (1-\omega)\pi^*_t$, (20) and (22), (19) is

$$\begin{aligned} \pi^*_t &= \frac{1-\beta\omega}{\omega}\kappa\theta_{t-1} + \frac{1-\beta\omega}{\omega}(e^1 + \kappa e^2)(\Psi^o_1 \Omega^f_t + \Psi^o_2 \theta_{t-1}) \\ \Longrightarrow \pi^*_t &= \frac{1-\beta\omega}{\omega}(e^1 + \kappa e^2)\Psi^o_1 \Omega^f_t + \frac{1-\beta\omega}{\omega}(\kappa + (e^1 + \kappa e^2)\Psi^o_2)\theta_{t-1}. \end{aligned} \tag{16}$$

Comparing the coefficients of (22) and (23), I obtain

$$\begin{aligned} A^o &= \frac{1-\beta\omega}{\omega}(e^1 + \kappa e^2)\Psi^o_1, \\ B^o &= \frac{1-\beta\omega}{\omega}(\kappa + (e^1 + \kappa e^2)\Psi^o_2), \end{aligned}$$

where e^i is normal unit vector with i-th element 1. By (22), equilibrium inflation rate is $\pi_{t+1} = (1-\omega)(A^o \Omega^f_t + B^o \theta_{t-1})$. Thus

$$\pi_\theta = (1-\omega)B^o.$$

Put $C^o = \kappa^{-1}(e^1\kappa^{-1} + e^2)$ and $E^f S_\theta = \Psi^o_2$.

By (7) and (11), in equilibrium, optimal monetary policy rule under discretion is

$$\begin{aligned} & (1+\tau)(1-\omega)B^o E^{cb}_{t-1}\pi_t + \lambda(\theta_{t-1} + E^{cb}_{t-1}v_t - E^{cb}_{t-1}w_t) = 0 \\ \Longrightarrow\ & (1+\tau)(1-\omega)B^o\Big[(1-\omega)A^o\Gamma^{cb}\Omega^{cb}_t + (1-\omega)B^o\theta_{t-1}\Big] + \lambda(\theta_{t-1} + E^{cb}_{t-1}v_t - E^{cb}_t w_t) = 0 \\ \Longrightarrow\ & \theta_{t-1} = \frac{1}{\lambda + (1-\omega)(1+\tau)(B^o)^2}\Big(\lambda e^3 - \lambda e^2 - (1+\tau)(1-\omega)^2 B^o A^o\Big)\Gamma^{cb}\Omega^{cb}_t. \end{aligned}$$

Comparing the coefficients of (20) and (24), I can calculate the undetermined coefficients. [8]

[8] In precise, I first guess the value of Ψ, calculate A^o, B^o and find new value of Ψ. Iterating until convergence, I obtain the true value of the coefficients.

Solving the Model under Transparent Regime

The solution method is analogous to that of the opaque regime. Assume that the firms' belief about monetary policy is

$$\theta_{t-1} = \Theta^t \Gamma^{cb} \Omega_t^{cb}.$$

In this regime, firms receive the central bank's information Ω_t^{cb}. Thus, the private sector's expectation of the aggregate shock can be written by

$$E^f S_t = \Psi^t \begin{pmatrix} \Omega^f \\ \Omega^{cb} \end{pmatrix}.$$

Firms' pricing strategy is of the form such as

$$\pi_t^* = A^t \Omega_t^f + D^t \Omega_t^{cb} + B^t \theta_{t-1}.$$

Using these equations, by the same way in the opaque regime, I obtain the following relation:

$$\begin{aligned} A^t &= [(1-\beta\omega)(e^1 + \kappa e^2)]\Psi_1^t, \quad B^t = \frac{(1-\beta\omega)}{\omega}, \\ K^t &= \frac{1-\beta\omega}{\omega}(e^1 + \kappa e^2 \Psi_2^t + \beta A^t \Psi_2^t). \end{aligned}$$

In equilibrium, inflation rate is

$$\pi_{t+1} = (1-\omega)(A^t \Omega_t^f + D^t \Omega_t^{cb} + B^t \theta_{t-1}).$$

The first order condition of the discretionary monetary policy has the same form as before. Hence, eventually, I obtain

$$\theta_{t-1} = \frac{1}{\lambda + (1-\omega)(1+\tau)(B^t)^2}\Big[(1+\tau)\lambda(e^3 - e^2) + (1-\omega)(B^t e^4 - (1-\omega)B^t(A^t + K^t(\Gamma^{cb})^{-1})\Big]\Gamma^{cb}\Omega_t^{cb}.$$

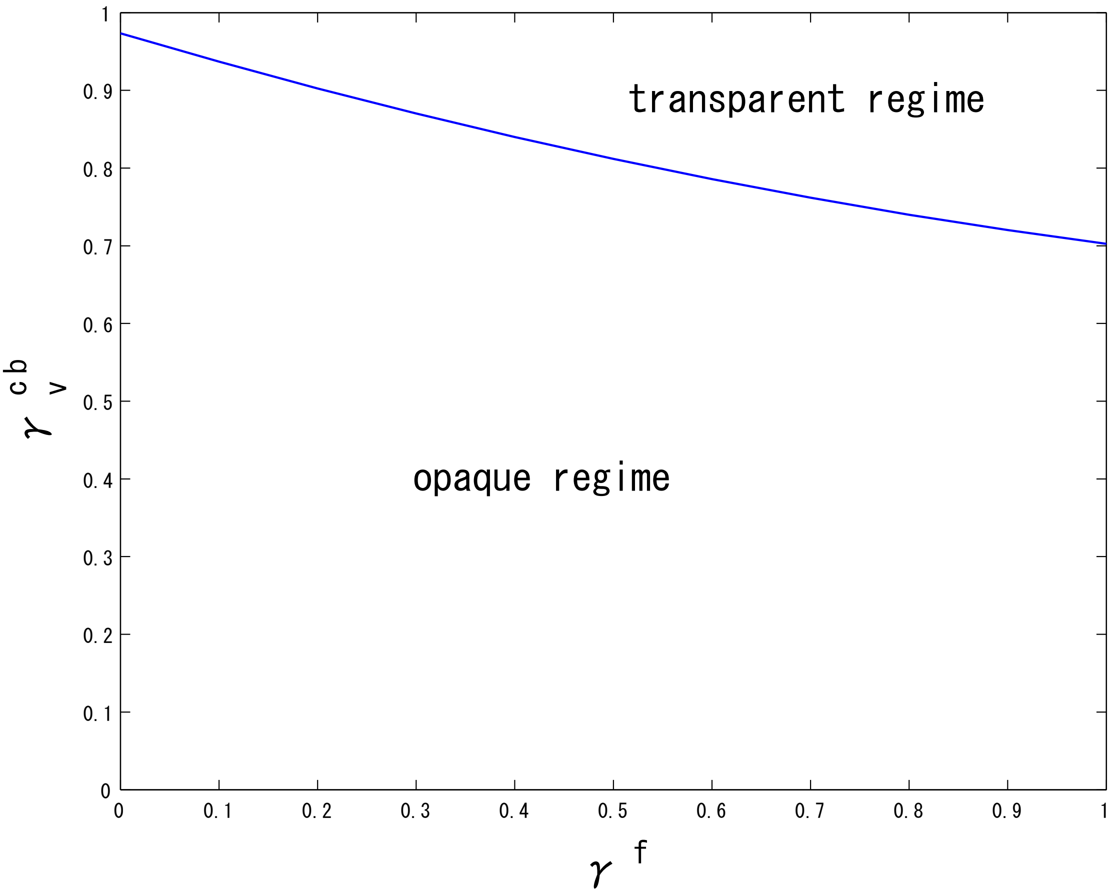

Figure 1: One of the key elements for welfare comparison is the firms' informational quality.

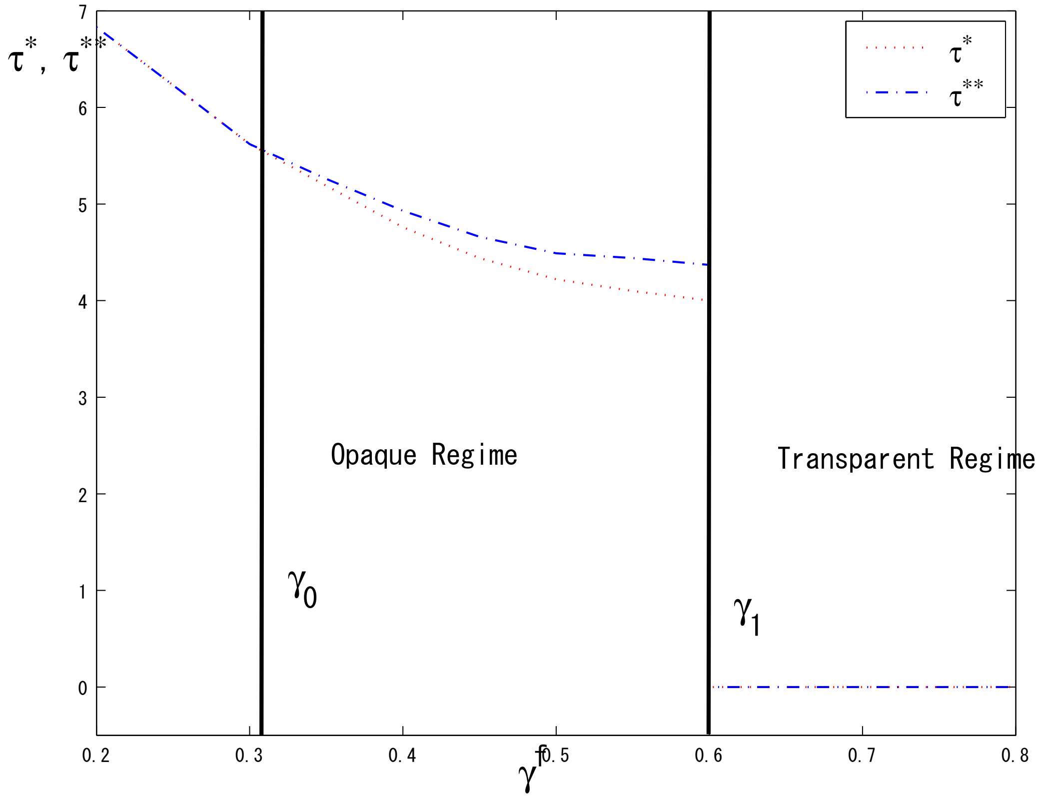

Figure 2: $\tau^{**} = \tau^{*}$ if $\gamma^{f} \leq \gamma_{0}$ and $\gamma^{f} > \gamma_{1}$. $\tau^{**} > \tau^{*}$ if $\gamma_{0} < \gamma^{f} < \gamma_{1}$.