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Does Model Uncertainty Lead to Less Central Bank Transparency?

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Abstract

This paper discusses the problem of monetary policy transparency in a simple static robust control framework. In this framework, we identify two sources of monetary policy uncertainty. First, we identify the uncertainty about the central bank's inflation stabilization preferences, which affects the private sector's inflation expectations and therefore the realized inflation and output. On the other hand, uncertainty means that central bank is unsure about its model, in the sense that there is a group of approximate models that it also considers as possibly true and its objective is to choose a rule that will work under a range of different model specifications. We find that robustness reveals the emergence of a precautionary behaviour of the central bank in the case of unstructured model uncertainty, reducing thus central bank's willingness to choice a high degree of monetary policy transparency.

Keywords *:* central bank transparency, min-max policies, model uncertainty, robust control.

JEL classification : E50, E52, E58

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1 Introduction

Central bank transparency has become one of the main features of monetary policy-making during the last decade. However, despite the recognized academic literature on the central bank independence, research in favour of transparency of monetary policy is relatively new (Eijffinger, Hoeberichts and Shaling, 2000; Cukierman, 2001; Geraats, 2002, 2004 and Demertzis and Hughes Hallet, 2003) and the findings of the transparency literature seem to be not irrefutable. There appears also to be an inconsistency between the effects emphasized in the theoretical literature and the motives for central bank transparency in practice (Geraats, 2002). Indeed, theoretical models show that transparency has the potential to reduce uncertainty and to enhance the credibility of monetary policy. In addition, transparency may affect the incentives that policymakers face to manipulate private sector beliefs through signaling and reputation building. In other words, when monetary policy decisions are intended to offset economic shocks, private information gives the central bank greater flexibility to stabilize the economy.

These theoretical considerations on central bank transparency often rely on uncertainty effects generated by asymmetric information and are likely to depend on the specific context of uncertainty. Transparency refers to the absence of information asymmetries between monetary policymakers and the private sector. Perfect transparency corresponds to a situation of symmetric information. This does not imply that monetary policymakers and the private sector have complete information about the economy and economic disturbances. Thus, to understand the optimal choice of the degree of transparency and his economic consequences, it is helpful to look, first, at the uncertainty generated by asymmetric information and second, at the uncertainty about the true structure of the economy.

There is currently a wide consensus that, subject to the constraints inherent in the structure of the economy, the central bank should minimize an appropriately discounted value of expected losses where the period loss function is given by a weighted average of the output and inflation deviations from their targets. Transparency about the policy process aimed at achieving this objective requires clarity about the structure of the economy (Cukierman, 2005). In this context, uncertainty about the structure of the economy has some interesting implications for the optimal transparency. However, in previous studies on central bank transparency, policymakers are assumed to know the true model of the economy and observe accurately all relevant macroeconomic variables. Uncertainty arises from the unknown future realisations of the supply shocks, assumed to be modeled according to some stochastic process whose properties is known. Unfortunately, the reality is much more complex. The policymaker's choice is made in the fare of tremendous uncertainty about the true structure of the economy, the impact policy actions have on the economy, and even about the current state of the economy. This complexity means that a certain degree of subjectivity enters into the actual decision making when deciding upon optimal monetary policy. In other words, the policymaker is unsure about his model, in the sense that there is a group of approximate models that he also considers as possibly true.

This raises the question of how a monetary policy rule should be selected in the face of uncertainty about the correct model of the economy. In fact, solutions to the expected value problem by standard optimal control methods do not deliver the best average performance if they are applied to an incorrect model. Because uncertainty is pervasive, it is important to understand how alternative policies work when the policymaker employs a model of the economy that is incorrect in unknown ways. Therefore, the resulting problem is one of robust control, in the sense of Hansen and Sargent (2003, 2004), where the objective is to choose a rule that will work under a range of different model specifications. The notion that policy decisions may be more robust if based on systematically distorted model of the economy is a key implication of the recent research on robustness control or uncertainty aversion literature (Onatski and Williams, 2003; Kilponen, 2003; Giordani and Söderlind, 2004; Leitemo and Söderström, 2004; Walsh, 2004).

This paper adapts robust control approach to the problem of the central bank transparency in a simple one-period positive theory monetary policy framework developed originally by Kydland and Prescott (1977) and Barro and Gordon (1983) in order to illustrate the basic intuition behind this new approach to uncertainty. In this framework, we identify two sources of uncertainty. First, the uncertainty concerning the central bank preferences (lack of transparency) affecting the private sector inflation expectations and thus inflation and output and second, the model uncertainty affecting the macroeconomic variables and the degree of transparency. In this context, it is particularly important to give an answer to the question whether model uncertainty affects the transparency of monetary policy as well as the welfare and the macroeconomic performance.

The rest of the paper is organised as follows. Section 2 sets up a one-period model of monetary policy. Section 3 derives the discretionary equilibrium under robust control. Section 4 derives the link between robustness and the degree of central bank transparency. Section 5 and 6 derives the macroeconomic performance and the welfare effects of central bank transparency. Section 7 summarises the main conclusions.

2 The model

In this section, we apply the basic idea of robust control to a simple one-period model of monetary policy developed originally in the seminal papers of Kydland and Prescott (1977) and Barro and Gordon (1983), in which policymaker sets inflation according to the following aggregate supply function:

$$x = \pi - \pi^e + \epsilon + h \tag{1}$$

where $x \equiv y - y^*$ is the output gap between the real aggregate output y and the natural rate of output $y^* > 0$, π is the inflation rate, π^e is the rationally expected inflation rate, ϵ is a random variable with mean zero and variance 1, and h is an additional deterministic disturbance component which introduce ambiguity of the model. The two disturbances terms and have different properties. The term ϵ is assumed to be a random error with a prior known stochastic properties, whilst h represents in the spirit of robust control (Hansen and Sargent, 2004) a totally ambiguous model misspecification error, in the sense that the policymaker is not able to assign any prior probability distribution to h. The model with $h = 0$ represents the reference model, while the models with $h \neq 0$ represent candidate models surrounding the reference model. The size of the distortion term h must be bounded as the policymaker has some information on the process. Hence, we assume that the magnitude of the square of the specification error verifies:

$$h^2 \leq \eta^2 \tag{2}$$

where the parameter η^2 bounds the square of the government's specification error h^2. Restriction (2), together with equation (1), define a set of models that the central bank considers as being possible outcomes in the sense that the policymaker does not know exactly the position of the aggregate supply in the space (x, π).

The central bank's preferences are described by the following standard quadratic loss function:

$$L_{cb} = \frac{1}{2}\left[(x - \widehat{x})^2 + \lambda\left(\pi - \widehat{\pi}\right)^2\right] \tag{3}$$

where central bank is assumed to stabilize output y and inflation π around their target values $\widehat{x} > 0$ and $\widehat{\pi}$, which is for simplicity fixed to zero. $\lambda > 0$ is the inflation aversion parameter of the central bank.

The issue of transparency arises when the public's perception about the bank's preferences on inflation $\bar{\lambda}$ differs from the values that the bank itself actually considers λ[1]. Equation 4 specifies the stochastic behavior of the parameter λ as follows:

$$\lambda = \bar{\lambda} - \mu, \quad \text{with} \quad E_{t-1}\left(\mu\right) = 0\ , \ \operatorname{Var}\left(\mu\right) = \sigma_{\mu}^2 \tag{4}$$

This implies that the public is correct on average, but may be mistaken when making guesses about the central bank preferences in individual cases or at certain points in time. σ_{μ}^2 measures the degree of opacity of the central bank's inflation stabilization preferences. If the variance of the preference shock σ_{μ}^2 goes up (goes down), the central bank becomes less(more) transparent respectively.

3 Discretionary equilibrium

According to the robust control approach, in order to hedge against the model ambiguity, the policymaker makes a particular subjective assessment of h . In other words, he chooses the worst case $(h \neq 0)$ at any given π^e and then designs corresponding monetary policy rule π which maximizes the utility at given h. In

[1]In the transparency literature, misunderstandings about the true value of the preference parameters λ can be identified as political transparency in line with Hughes Hallet and Viegi (2001) or Geraats (2002).

order to introduce such subjective assessment of h into the decision making problem, we replace the standard quadratic utility function (4) by an "uncertainty aversion" utility function and we seek a solution to the following problem:

$$\min_{\pi}\max_{h}\ L'_{cb} = \frac{1}{2}\left[(x-\widehat{x})^2 + \lambda\left(\pi-\widehat{\pi}\right)^2\right] - \frac{\theta}{2}h^2 \tag{5}$$

The design of a robust policy rule becomes now a min-max problem, where the optimal level of inflation is found by minimizing L'_{cb} , with h being chosen to maximize L'_{cb} subject to the linear constraint (1). θ is a fixed penalty parameter which reflects the central banker's desired degree of robustness. $\theta > 1$ can be interpreted as a Lagrangian multiplier on constraint (2). The value $\theta = 1$ is the breakdown point to be discussed later. The value for θ would be endogenous in the constrained Lagrangian, and it would be associated to the specific η value used in the constraint (2). The way the problem is written here, θ is chosen directly and the constraint is adapted accordingly. Note also that larger values of θ imply smaller sets of models so that θ is an indicator of the precautionary behaviour of the authorities. In other words, the more θ is close to one, the more the central bank is insuring about the accuracy of the model it uses. In the opposite case, as $\theta \to +\infty$, the central bank believes that its model is a good approximation of the true model of the economy. In the limit case where $\theta = +\infty$, there is no misspecification and the central bank is convinced that the model it uses is the true one.

From the first order conditions for π and h in the problem (5), we obtain respectively the following solutions for the central bank robust policy rule and the nature (evil agent) worts-case shock :

$$\pi(h) = \frac{\pi^e + \widehat{x} - \varepsilon - h}{1+\lambda} \tag{6}$$

$$h(\pi) = \frac{\pi - \pi^e + \varepsilon - \widehat{x}}{\theta - 1} \tag{7}$$

and then solving the system of equations (6) and (7), we obtain:

$$\pi(\theta) = \frac{\theta}{\theta + \lambda(\theta-1)}(\pi^e - \varepsilon + \widehat{x}) \tag{8}$$

$$h(\theta) = -\frac{\lambda}{\theta + \lambda(\theta-1)}(\pi^e - \varepsilon + \widehat{x}) \tag{9}$$

where $\pi(\theta)$ gives the central bank's (robust) best reaction function for setting π as a

function of π^e, while $h(\theta)$ determines the worst case model, given π^e and the central bank's setting $\pi(\theta)$. Then, using equation (8) and assuming rational expectations of the private sector yields:

$$E(\pi) = E\left[\frac{\theta}{\theta + \lambda(\theta-1)}\right](\pi^e + \widehat{x}) \tag{10}$$

Using $E(\pi) = \pi^e$ and a second order Taylor approximation, we write (10) as

$$\pi^e = \frac{\left[\theta + \bar{\lambda}(\theta - 1)\right]^2 + (\theta - 1)\sigma_\mu^2}{\left[\theta + \bar{\lambda}(\theta - 1)\right]^2 \left[\bar{\lambda}(\theta - 1)\right] - \theta(\theta - 1)^2\sigma_\mu^2}\widehat{x} \tag{11}$$

where the expected inflation is positive $\pi^e > 0$ because there is a source of a positive inflation bias in the model ($\widehat{x} > 0$). Then, given (11), we can solve for the equilibrium. Inserting inflation expectations (11) into equations (8) and (9) and solving the resulting system delivers the inflation, the output gap and the worst-case shock in discretionary equilibrium as follows:

$$\pi = \frac{\theta}{\theta + \lambda(\theta - 1)}\left[\frac{\left[\theta + \bar{\lambda}(\theta - 1)\right]^3 \widehat{x}}{\left[\theta + \bar{\lambda}(\theta - 1)\right]^2 \bar{\lambda}(\theta - 1) - \theta(\theta - 1)^2\sigma_\mu^2} - \varepsilon\right] \tag{12}$$

$$x = \widehat{x} - \frac{\theta\lambda}{\theta + \lambda(\theta - 1)}\left[\frac{\left[\theta + \bar{\lambda}(\theta - 1)\right]^3 \widehat{x}}{\left[\theta + \bar{\lambda}(\theta - 1)\right]^2 \bar{\lambda}(\theta - 1) - \theta(\theta - 1)^2\sigma_\mu^2} - \varepsilon\right] \tag{13}$$

$$h = -\frac{\lambda}{\theta + \lambda(\theta - 1)}\left[\frac{\left[\theta + \bar{\lambda}(\theta - 1)\right]^3 \widehat{x}}{\left[\theta + \bar{\lambda}(\theta - 1)\right]^2 \bar{\lambda}(\theta - 1) - \theta(\theta - 1)^2\sigma_\mu^2} - \varepsilon\right] \tag{14}$$

4 Robustness and transparency

In this model uncertainty framework, the robust policy rule is designed to perform reasonably well across a range of alternative models, but it has not been designed to be optimal relative to any particular model. In this context, it is particularly important to give an answer to the question whether model uncertainty affects the transparency of monetary policy. In order to highlight this question, it is useful to find a relation between the degree of model robustness θ and the variance of the central bank preference shock σ_μ^2 . For this reason, we use the expected inflation equation (11), where $\pi^e > 0$ because a positive inflation bias ($\widehat{x} > 0$) is assumed in this model. To be consistent with $\pi^e > 0$, the condition

$$\left[\theta + \bar{\lambda}(\theta - 1)\right]^2 \left[\bar{\lambda}(\theta - 1)\right] - \theta(\theta - 1)^2\sigma_\mu^2 > 0$$

is required. By arranging the terms of this condition, we get the inequality:

$$\sigma_\mu^2 < \frac{\left[\theta + \bar{\lambda}(\theta - 1)\right]^2 \bar{\lambda}}{\theta(\theta - 1)} \tag{15}$$

This inequality (15) can be used to generate a link between the degree of model robustness θ and the variance of the central bank preference shock σ_μ^2. The intuition behind this link is that there is an upper limit for the degree of central bank opacity (lack of transparency) σ_μ^2 , which is a function of the degree of model robustness θ. In this perspective, we verify the monotonicity of the function

$$f(\theta) = \frac{\left[\theta + \bar{\lambda}(\theta - 1)\right]^2 \bar{\lambda}}{\theta(\theta - 1)} \tag{16}$$

by taking the following first order condition :

$$f\,'(\theta) = -\frac{\left[\theta + \bar{\lambda}(\theta - 1)\right]\left[\theta - \bar{\lambda}(\theta - 1)\right]}{\theta^2(\theta - 1)^2} \tag{17}$$

Equation (17) reveals that monotonicity of $f\,'(\theta)$ depends crucially on the sign of the term $\left[\bar{\lambda}(\theta - 1) - \theta\right]$. To provide a further clarification of the sign of this term, we can determine the relation between the degree of model robustness and the degree of central bank opacity. In this respect, the expression $\left[\bar{\lambda}(\theta - 1) - \theta\right]$ can be illustrated in the Figure 1:

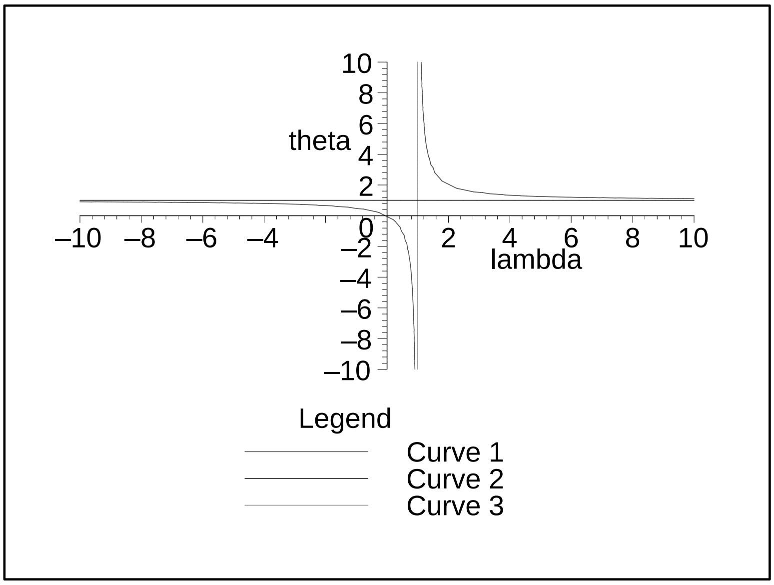

Figure 1: The monotonicity of $\left(\bar{\lambda}(\theta - 1) - \theta\right)$

where the curve in this figure represents all the points satisfying the condition: $\left[\bar{\lambda}(\theta - 1) - \theta\right] = 0$ (with $\bar{\lambda} = 1$ and $\theta = 1$ being two asymptotes). Here, we just take into account the region A delimited by $\bar{\lambda} \geq 1$ and $\theta > 1$. Our discussion here focuses solely on the region A which represents generally the most of possible cases where an independent central bank has a rather high degree of model robustness. It becomes also obvious that the area bordered by the above three lines is negligible in the whole region A. For this region, we verify the following relation:

$$f\,'(\theta) > 0 \tag{18}$$

This result represents the more realistic condition on the current central banking practice. In fact, the majority of central banks presently attach a more important weight to inflation stabilization than to the output gap. On the other hand, though the central bank's reference model could be misspecified to some extend, the extent of specification error is restricted (see equation 2), which implies that the degree of model robustness θ is usually to a large extent higher than the break point 1. From this result, we derive the following proposition.

Proposition 1 *There are a positive relationship between the degree of model robustness, θ, and the degree of central bank opacity (lack of transparency) σ_μ^2. In other words, the limits within which the central bank may assign alternative values in σ_μ^2, enlarge with the increase in the degree of model robustness, θ, meaning that central bank's monetary policy can be less transparent.*

Proof. According to equation (18), we obtain the following result $\partial f(\theta)/\partial\theta > 0$. This result imply a less restrictive condition on σ_μ^2 according to equation $\sigma_\mu^2 < f(\theta)$ (15). This imply an enlargement of the limits within which the uncertainty of central bank preferences, σ_μ^2, may take higher values than before an increase in the degree of model robustness, θ. ■

The intuition behind this result is that the less a central bank believes in the robustness of the model of the economy, the more it could be reluctant to reveal information on its preferences about inflation stabilization.

5 Macroeconomic effects

The discretionary equilibrium solutions permit as to investigate now how the degree of central bank opacity, σ_μ^2, affects the optimal values of the macroeconomic variables. Considering equations (19), (12) and (13), and differentiating with respect to the degree of central bank opacity σ_μ^2 , we obtain respectively for expected inflation, inflation and output gap the following results:

$$\frac{\partial \pi^e}{\partial \sigma_\mu^2} = \frac{\left[\theta A^2 + \theta(\theta-1)^2\sigma_\mu^2\right](\theta-1)^2\theta}{\left[\bar{\lambda}(\theta-1)A^2 - \theta(\theta-1)^2\sigma_\mu^2\right]^2}\hat{x} + \frac{\theta(\theta-1)^2}{\bar{\lambda}(\theta-1)A^2 - \theta(\theta-1)^2\sigma_\mu^2}\hat{x} \tag{19}$$

where $A \equiv \bar{\lambda}(\theta-1)+\theta$.

$$\frac{\partial \pi}{\partial \sigma_\mu^2} = \frac{\theta^2(\theta-1)^2A^3\hat{x}}{(\lambda(\theta-1)+\theta)\left(A^2\bar{\lambda}(\theta-1)-(\theta-1)^2\theta\sigma_\mu^2\right)^2} \tag{20}$$

$$\frac{\partial\left|x-\hat{x}\right|}{\partial \sigma_\mu^2} = \frac{\lambda\theta^2(\theta-1)^2A^3\hat{x}}{(\lambda(\theta-1)+\theta)\left(A^2\bar{\lambda}(\theta-1)-(\theta-1)^2\theta\sigma_\mu^2\right)^2} \tag{21}$$

From the above results, we derive the following propositions concerning the effects of transparency on macro variables.

Proposition 2 *The more the central bank's opacity σ_μ^2 is important, the higher the inflation expectations π^e, the inflation π and the output gap x will be.*

Proof. From equations (19), (20) and (21) it is straightforward to find that:

$$\frac{\partial \pi^e}{\partial \sigma_\mu^2} > 0, \quad \frac{\partial \pi}{\partial \sigma_\mu^2} > 0 \quad \text{and} \quad \frac{\partial |x - \hat{x}|}{\partial \sigma_\mu^2} > 0.$$

■

The intuition behind this proposition is that as the central bank opacity about its preferences increases, private agents tend to move up their inflationary expectations because of the risk to underestimate the inflation. On the other hand, to realize the output objective, central bank should raise more the inflation rate subsequent to the move up of the inflationary expectations. Consequently, the level of the output gap will be higher when the change on the central bank opacity (lack of transparency) becomes more important.

Concerning now the inflation and output gap volatility due to the change on the central bank transparency, equations (12) and (13) give as respectively the variances of the inflation and the output gap as:[2]

$$\text{Var}(\pi) = \frac{\theta^2(\theta-1)^2}{\left[\bar{\lambda}(\theta-1)+\theta\right]^4}\sigma_\mu^2 \tag{22}$$

$$\text{Var}(x) = \frac{\theta^2\bar{\lambda}^2}{\left[\bar{\lambda}(\theta-1)+\theta\right]^2}\left[\frac{\theta-1}{\bar{\lambda}(\theta-1)+\theta} - \frac{1}{\bar{\lambda}}\right]^2 \sigma_\mu^2 \tag{23}$$

Proposition 3 *The more the central bank's opacity σ_μ^2 is important, the more the volatility of the output gap and the inflation will be important.*

Proof. Differentiating equations (22) and (23) with respect to σ_μ^2 gives respectively:

$$\frac{\partial \text{Var}(\pi)}{\partial \sigma_\mu^2} = \frac{\theta^2(\theta-1)^2}{\left[\bar{\lambda}(\theta-1)+\theta\right]^4} > 0 \tag{24}$$

$$\frac{\partial \text{Var}(x)}{\partial \sigma_\mu^2} = \frac{\theta^2\bar{\lambda}^2}{\left[\bar{\lambda}(\theta-1)+\theta\right]^2}\left[\frac{\theta-1}{\bar{\lambda}(\theta-1)+\theta} - \frac{1}{\bar{\lambda}}\right]^2 > 0 \tag{25}$$

■

Finally, we consider the interaction between the uncertainty about the central bank preferences σ_μ^2 and the model uncertainty which is characterized by the misspecification term h. We derive the following proposition.

Proposition 4 *The misspecification doubts of the central bank about the true structure of the economy, h , are positively related to the central bank's opacity σ_μ^2 .*

Proof. From the derivation of equation (21) with respect to σ_μ^2, we obtain:

$$\frac{\partial |h|}{\partial \sigma_\mu^2} = \frac{\lambda\theta(\theta-1)^2 A^3 \hat{x}}{(\lambda(\theta-1)+\theta)\left(A^2\bar{\lambda}(\theta-1) - (\theta-1)^2\theta\sigma_\mu^2\right)^2} > 0 \tag{26}$$

[2] We assume here $\hat{x} = 0$, for simplifying the calculate.

■

The preceding results reveal that a larger degree of central bank opacity requires that central bank will act more aggressively. This brings better economic stability performance, but it does not come without costs. On the other hand, the possible misspecification doubts of the central bank will be negatively related to the monetary policy transparency.

6 Welfare effects

We consider in this section how the central bank's expected loss function L'_{cb}varies with the degree of model robustness θ and the degree of central bank's opacity σ_μ^2. In this respect we insert the equilibrium values of π, x and h in the central bank's expected loss function (5) and we obtain the following result:

$$L'_{cb} = \frac{E}{2}\left[\left(\frac{\theta\lambda}{\theta+\lambda(\theta-1)}\right)^2\left(\frac{\left[\theta+\bar{\lambda}(\theta-1)\right]^3\widehat{x}}{\left[\theta+\bar{\lambda}(\theta-1)\right]^2\bar{\lambda}(\theta-1)-\theta(\theta-1)^2\sigma_\mu^2}-\varepsilon\right)^2\right] \quad (27)$$

Taking into account that $E(\lambda)=\lambda$ and $\sigma_\varepsilon^2=1$, we get:

$$L'_{cb} = \frac{\theta\lambda}{2\left[\theta+\lambda(\theta-1)\right]}\left[\frac{\left[\theta+\bar{\lambda}(\theta-1)\right]^6\widehat{x}^2}{\left(\left[\theta+\bar{\lambda}(\theta-1)\right]^2\bar{\lambda}(\theta-1)-\theta(\theta-1)^2\sigma_\mu^2\right)^2}+1\right] \quad (28)$$

We examine, first, the impact of the uncertainty concerning the central bank's opacity on the central bank's expected losses and we derive the following proposition.

Proposition 5 *The greater the central bank opacity is, the higher the expected losses of central bank will be.*

Proof. From equation (28), we derive with respect to σ_μ^2 and we easily obtain:

$$\frac{\partial L'_{cb}}{\partial\sigma_\mu^2} = \frac{\lambda\theta^2(\theta-1)^2\left[\theta+\bar{\lambda}(\theta-1)\right]^6\widehat{x}^2}{\left[\theta+\lambda(\theta-1)\right]\left\{\left[\theta+\bar{\lambda}(\theta-1)\right]^2\bar{\lambda}(\theta-1)-\theta(\theta-1)^2\sigma_\mu^2\right\}^3} > 0 \quad (29)$$

■

It is not surprising that this increase of uncertainty of the central bank preferences will induce a further higher loss. Indeed, as has been demonstrated in the previous section, an increase of the uncertainty about the central bank's preferences generates a higher volatility of inflation and the output gap.

Finally, we consider the effect of the model uncertainty on the central bank's expected loss function. Given the imprecise interaction between the of model uncertainty, the central bank's opacity and the central bank's expected losses, we consider two particular cases. First, the case where there is no uncertainty on central bank's preferences, (i.e. the case of full transparency) and second, the case where there is a certain degree of uncertainty on central bank's preferences (i.e. relative opacity).

In the first case, since $\sigma_\mu^2 = 0$, we put $\lambda = \bar{\lambda}$ and then the expected loss function becomes

$$L'_{cb} = \frac{1}{2}\left[\frac{\bar{\lambda}\theta}{\theta + \bar{\lambda}(\theta - 1)} + \frac{A\theta\hat{x}^2}{(\theta-1)^2\bar{\lambda}}\right] \tag{30}$$

Then, we derive (30) with respect to θ and we obtain:

$$\frac{\partial L'_{cb}}{\partial \theta} = -\frac{1}{2}\left[\frac{\bar{\lambda}(\theta-1) + 2\theta}{\bar{\lambda}(\theta-1)^3}\hat{x}^2 + \frac{\bar{\lambda}}{A^2}\right] \tag{31}$$

Equation (31) reveals that the more the model is robust, the less the central bank expected loss will be. This result is in line with the corresponding literature. Moreover, in the case where there is no model misspecification (i.e.$\theta \to \infty$), the central bank's expected loss receives its minimum value (the certainty equivalence case).

However, it becomes more interesting to re-evaluate this relation in the second case, in which opacity on the central bank preferences occurs. Unfortunately, analytical derivation in this case for the expected loss function with respect to θ is complicated. Nevertheless, using numerical simulations, we show that when the model used by the central bank becomes more accurate, the central bank's losses augment for any given degree of monetary policy transparency.

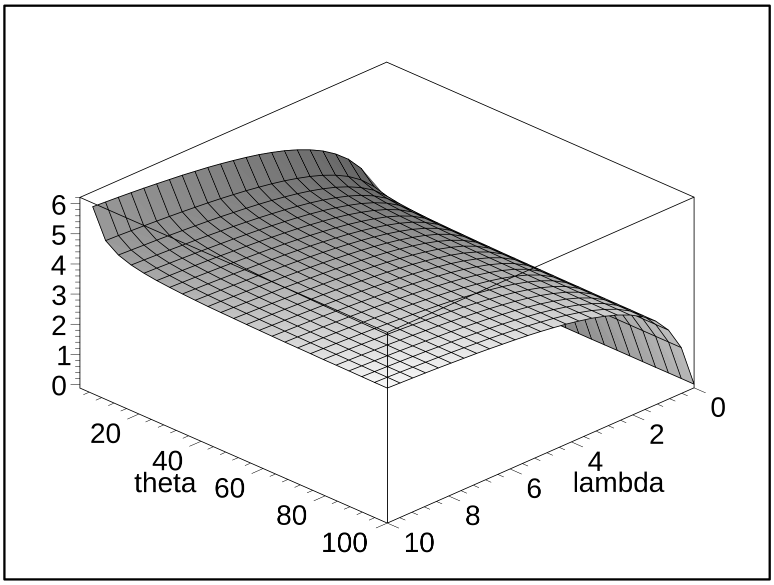

Figure 2: The central bank's losses

In Figure 2 we report the results of our numerical simulations and we illustrate a negative relationship between the degree of model robustness θ and the central bank's losses L'_{cb}. Finally, using the results of these two cases, we can derive the following proposition:

Proposition 6 *For any given degree of transparency, the central bank's expected loss decreases with the degree of model robustness.*

Proof. From equation (31) and the simulation results reported in Figure 2, it is straightforward to find that : $\partial L'_{cb}/\partial\theta < 0$ ■

In this framework, the expected loss is affected by two underlying sources of uncertainty. For any given degree of central bank transparency, central bank can always benefit from the improvement of the model robustness improving thus the macroeconomic performances.

7 Conclusions

In this paper, we adapt the robust control approach on uncertainty in a simple static one-period monetary policy game framework to study the problem of the monetary policy transparency. In this framework, we identify two sources of uncertainty: the uncertainty about the central bank preferences (central bank's opacity or transparency) and the model uncertainty concerning the true structure of the economy. In this context, it is particularly important to give an answer to the question whether model uncertainty affects the transparency of monetary policy as well as the welfare and the macroeconomic performance.

In this environment, we show that robustness or "uncertainty aversion" reveals the possibility of a precautionary behaviour of the central bank in the case of potential specification errors surrounding the model, reducing thus central bank's willingness to choice a high degree of monetary policy transparency. More precisely, there appears that the limits within which the central bank may assign different values in preference uncertainty enlarge with the increase in the degree of model robustness, meaning that central bank's monetary policy may potentially be less transparent.

On the other hand, we show also that the more the central bank's opacity is important, the higher the inflation expectations, the inflation, the output gap and their volatility will be important. These results reveal that a larger degree of central bank opacity requires that central bank will act more aggressively, generating thus a better economic stability performance. Finally, we show that the central bank expected loss is affected by two underlying sources of uncertainty. For any given degree of central bank transparency, central bank can always benefit from the improvement of the model robustness improving thus the macroeconomic performances.

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