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How multiplicative uncertainty affects the trade-off between information disclosure and stabilisation policy?

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Abstract: In an economy characterised by Keynes' "beauty contest", policymakers can either disseminate their own information and abstain from stabilisation policy, or use an informational advantage to undertake active policy intervention. The contribution of this paper is to analyse how such a trade-off is affected by Brainard's conservatism principle. We show that multiplicative uncertainty reduces the incentive for policy activism and weakens the argument for imperfect disclosure of the policymaker's private information. Notably, a sufficient high degree of multiplicative uncertainty in the transmission of policy intervention would call for full disclosure of public information in the presence of stabilisation policy.

Keywords: Multiplicative uncertainty; heterogeneous private information; optimal information disclosure; policy intervention; strategic complementarities.

JEL classification numbers: C72, D62, D82, E58.

Introduction

It is generally recognised that central banks operate in an environment characterised by great uncertainty regarding not only the information available to the private sector, but also the true economic structure and transmission mechanisms. As it is observed by the Bank for International Settlements (BIS, 2007), "in the light of massive and ongoing structural changes, our understanding of economic processes may even be less today than it was in the past." Indeed, there is an increase in fundamental uncertainties about how the economy works, particularly in the aftermath of the 2007/2008 global financial crisis.

Besides these uncertainties, monetary policy decisions are increasingly concerned with financial stability that could disturb macroeconomic stability. The recent global financial crisis and Eurozone sovereign debt and banking crises have precipitated massive interventions in the financial market by central banks across the world through large purchases of public and private assets. The bank of Japan goes even further by buying shares in the domestic stock market. Indeed, macroeconomic performance depends largely on the "beauty contest" that characterises the financial market as well as on monetary policy conceived to affect the expectations of market participants about the future path of macroeconomic variables.

Market participants put strong pressures on the central bank to be fully transparent, through frequent and clear communication, about its private economic information (data, policy model, and forecasts), policy objectives, the procedure leading to policy decisions, and control errors. In fact, the need to guide the expectations of financial market participants, whose appetite for information has increased as financial markets have become broader and deeper, is one of the most important reasons for independent central banks to become more transparent, apart from being accountable and legitimate (Blinder et al. 2001, Blinder et al. 2008, Crowe and Meade 2008).

The question of whether higher central bank transparency is beneficial to the conduct of policy and promotes macroeconomic and financial stability has triggered a controversial debate. Among the different strands of the literature on this issue,[1] the one initiated by

[1] Following the seminal work of Cukierman and Metzler (1986a), a large theoretical and empirical literature on central bank transparency has been developed. See, e.g., Nolan and Schaling (1998), Faust and Svensson (2001), Chortareas *et al*. (2002), Eijffinger and Geraats (2006), and Demertzis and Hughes Hallet (2007),

Morris and Shin (2002) has more pertinently captured the game between the central bank and financial participants by considering their strategic behaviour in the spirit of the beauty contest metaphor mentioned in Keynes's General Theory (1936). They have identified the potentially damaging consequences of public information dissemination by policymakers when individual agents adopt an objective function characterised by both fundamental and strategic motives displayed in Keynes' beauty contest parable, and hold heterogeneous private information regarding economic fundamentals.[2] Greater transparency regarding the disclosure of public information may not lead to welfare improvement because according to the theory of the second best, removing one distortion may not always lead to a more efficient allocation when other distortions such as strategic motives are present.

The important finding of Morris and Shin (2002) has originated a growing strand of literature focusing on the equilibrium and welfare properties of economies characterised by dispersed private information and the implications of optimal stabilisation policy (Hellwig 2005, Angeletos and Pavan 2004, 2007a,b, Cornand and Heinemann 2008, and James and Lawler 2011, 2012a,b, 2015). The central issue in these studies is the important trade-off for policymakers between disseminating their own information and abstaining from stabilisation policy on the one hand, and using an informational advantage to undertake active policy intervention on the other hand. James and Lawler (2012a) consider additive uncertainty in the transmission of policy action and show that such uncertainty does not change the conclusions of this literature because the principle of certainty equivalence applies in linear-quadratic models.

The aim of this paper is to examine whether the policymaker should fully disclose public information when the transmission of stabilisation policy is impaired by multiplicative uncertainty in an environment characterised by private agents' strategic behaviour of the type observed in a beauty contest. This paper builds upon an abstract

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Dincer and Eichengreen (2008), Spyromitros and Tuysuz (2012), Papadamou et al. (2015, 2016). Especially, moving towards more transparency reduces stock market volatility considerably, implying significant benefits for financial stability (Papadamou et al. 2014), but too high degree of transparency might induce opposite effects (Horváth and Vaško 2016). See Geraats (2002), Blinder et al. (2008), and Eijffinger and van der Cruijsen (2010) for a survey of the literature.

[2] Svensson (2006) presents a significant criticism of this anti-transparency result, arguing that restrictions on information parameters for their result to hold are very specific and empirically implausible. If one assumes plausible values for underlying parameters, then more precise public information actually increases social welfare. In response to this criticism, Morris et al. (2006) have argued that when the coordination motive is high, the hurdle rate of precision of public information for this to be true can actually be quite high.

framework due to Morris and Shin (2002) and James and Lawler (2011). In this framework, the direct role that central banks play in shaping macroeconomic outcomes through active policy intervention changes the relationship between the quality of public information and social welfare. We show that the famous Brainard's (1967) conservatism principle also applies to this framework in so far as multiplicative uncertainty significantly reduces the usefulness of the activist policy and substantially modifies the conclusions to be drawn with regard to the desirability of public information disclosure.

We demonstrate that, when policy is conducted according to an optimally-designed rule, the presence of multiplicative uncertainty greatly restrains the cases where the result of James and Lawler (2011) holds. Brainard's conservatism principle substantially reduces the desirability of imperfect disclosure of public information. This is because on the one hand, opacity could improve social welfare in the presence of strategic complementarity between private actions by allowing the activist policy to surprise private agents; on the other hand, opacity amplifies the detrimental effect of multiplicative uncertainty on the effectiveness of activist policy and hence could deteriorate social welfare. The negative effect of opacity could become predominant if the degree of multiplicative uncertainty is sufficiently high. In this case, the best choice for policymakers would be to combine an optimal policy rule with full disclosure of their own information.

The reason for which multiplicative uncertainty could induce significant modification in policy decisions and economic results is that it incites policymakers to react cautiously to economic disturbances (Brainard 1967). By 'cautiously' it is generally meant that policy instrument should be moved by less than in the absence of multiplicative uncertainty. The certainty equivalence would not hold because the stabilising influence of any intended adjustments in policy instrument has to be weighed against the macroeconomic volatility induced by uncertain effects of policy responses. Although some authors showed the contrary effects, Blinder (1998) observed that Brainard's result seemed to capture the way actual policymakers viewed their decisions. Empirical studies have shown that multiplicative uncertainty significantly affects the monetary policy decisions of central banks and the optimal policy under multiplicative uncertainty can account for a considerable portion of the observed gradualism (Sack 2000, and Lane 2003).

Of relevance to our paper are some recent studies relating multiplicative uncertainty with central bank transparency (Kobayashi 2003, Ciccarone and Marchetti 2009, and Dai 2010). Without introducing heterogeneous information about economic fundamentals, these studies have found that higher multiplicative uncertainty could improve social welfare when the central bank limits the disclosure of information about its preferences.

Some recent theoretical studies have extensively explored the implications of multiplicative uncertainty for monetary policy decision without considering the issue of central bank transparency. In Lawler (2007) and Henckel (2010), in the presence of non-atomistic labour unions, multiplicative uncertainty raises the incentive for a central bank to engineer an inflation surprise and justifies the delegation of monetary policy to the central bank that attaches a smaller relative weight to inflation stabilisation than does the society. Di Bartolomeo et al. (2009) advance that, under multiplicative uncertainty, a time inconsistency problem could arise even if monetary and fiscal authorities share a common target. For Di Bartolomeo and Giuli (2011), multiplicative uncertainty could induce either more or less aggressive effect on the final outcomes according to the kind of monetary and fiscal interactions. Using the robust control approach to re-examine the issue of parameter uncertainty, some authors find that the latter could amplify or attenuate the policy response according to parameters (Wieland 2000, Söderström 2002; Onatski and Stock 2002; Tetlow and von zur Muehlen 2001, 2004, Giannoni 2002, 2007, and Traficante 2013).

The remainder of the paper is organised as follows. Section 2 introduces multiplicative uncertainty into the beauty contest framework. Section 3 solves for the equilibrium. Section 4 investigates how multiplicative uncertainty modifies the desirability of full transparency for the policymaker and the effects of opacity on social welfare. Section 5 discusses our results as well as the implications of an alternative payoff function. Section 6 concludes.

1. The Model

We incorporate multiplicative uncertainty in a version of Morris and Shin's model (2002) based on a game that induces strategic behaviour in the spirit of the Keynes's beauty contest, extended by James and Lawler (2011) to attribute a potential role for stabilisation policy. Such uncertainty affects the way the policymaker (the government or its agent such

as the central bank) influences outcomes directly by its policy intervention and indirectly through the disclosure of information to the private sector.

The economy is populated by a continuum of private agents, indexed by *i* and uniformly distributed over the unit interval and by a benevolent policy maker. Agent *i* chooses his or her action $a_i \in \mathbb{R}$ to maximise the following payoff function:

$$u_i = -(1-r)(a_i - \theta - g)^2 - r(L_i - \bar{L}), \text{ with } \quad L_i = \int_0^1 (a_j - a_i)^2 dj \text{ and } \bar{L} = \int_0^1 L_j dj; \quad (1)$$

where $r \in (0,1)$ is a constant. The first term is a standard quadratic loss due to the distance between his or her own action a_i and the current value of economic fundamentals $(\theta + g)$, with θ denoting the underlying state that is assumed to be drawn from a uniform distribution over the real line as in Morris and Shin (2002), and g the effect of policymaker's action. The second is a beauty contest term penalising departures of agent *i*'s action L_i from the average action of all private agents $\bar{L}$, giving rise to an externality due to the fact that each individual tries to second-guess the decisions of other individuals in the economy. The game of second-guessing is socially inefficient because it is of a zero-sum nature. The parameter r represents the weight on this externality while $(1-r)$ is the weight assigned to the standard quadratic loss. The presence of the second term is responsible for the distinctive nature of Morris and Shin's results about central bank transparency. The parameter g represents the modification that James and Lawler (2011) brought to the payoff function of Morris and Shin (2002) and its appropriate adjustments allows the policymaker to fully neutralise the consequences of a variation in θ. In a macroeconomic context, one can consider that θ corresponds to an aggregate demand shock that leads the policymaker to take an action by appropriately adjusting g to offset its effects on the economy. The individual incentives generated by the kind of payoff function like (1), with the beauty contest motive characterised by a zero sum outcome, are perhaps most readily rationalised in the context of financial markets.

In this paper, we modify the definition of g given by James and Lawler (2011). It does not anymore represent the policymaker's instrument setting that resembles to a lump-sum transfer to private agents but the uncertain effect of policy decision on these agents' payoff function. We assume that the transmission mechanism from the policymaker's action to the

payoff of each private agent is affected by multiplicative uncertainty. Due to this uncertainty, the identity between the value of policy instrument and the final effect of the policymaker's action on the payoff of private agents does not hold anymore. In contrast, James and Lawler (2012a) consider additive uncertainty about the effect of policy action.

The action of the policymaker follows a commitment rule that sets the instrument value (or policy action) equal to ρz with z being a noisy signal of θ observed by the policymaker.[3] The value of the policy-rule parameter, ρ, is public knowledge and is chosen by the policymaker to maximise the expected value of social welfare, W, defined as $W \equiv \frac{1}{1-r}\int_0^1 u_i di$. Representing optimal policy as a linear decision rule (i.e., a linear function of the policymaker's current information) is justified by the nature of the linear quadratic structure that ensures the linearity of best response functions.

Under multiplicative uncertainty, the relationship between policymaker's action (ρz) and its effect on the payoff of private agents is characterised by:

$$g = (1+\omega)\rho z, \tag{2}$$

where $\omega \sim N(0,\sigma_\omega^2)$ is a multiplier disturbance that affects the transmission mechanism of policy action.[4] We assume that both the policymaker and the private sector have no exact knowledge of the precise value of ω before its realisation and hence are not able to respond to this shock in their actions.

We now discuss the informational assumptions adopted in our analysis. When choosing a_i, agent i is uncertain about the true state of the economy θ. Similarly, before setting its policy instrument value, the policymaker is assumed not to have full information on the realisation of θ and observes a noisy signal of θ:

$$z = \theta + \phi, \tag{3}$$

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[3] Subsequently, the degree of precision of the public signal as well as the rule parameter ρ will be optimally chosen such that the associated optimal policy rule is time consistent. Commitment is preferable in terms of social welfare to discretion. Furthermore, conducting policy in a discretionary fashion would imply that the present framework was characterized by multiple equilibria, making the coordination of private expectations a more complex issue.

[4] James and Lawler (2012a) have considered an alternative policy rule that is function of public signal, y, and is subject to an additive transmission mechanism disturbance that affects the relationship between the instrument setting and the economic outcome.

where the noise term, $\phi \sim N(0,\sigma_\phi^2)$, is assumed to be independent of θ. The policymaker's expectation of θ conditional on the signal z is simply the value of z itself, i.e., $\mathrm{E}_g(\theta|z) \equiv \mathrm{E}_g(\theta) = z$.

The policymaker is assumed to introduce an additional noise in the public announcement revealing his observation of z. The distinction between the information on which policy is based and what is released to the public allows us to consider the consequences of differing degrees of disclosure or transparency. The public signal, y, observed by all private agents, is determined according to a disclosure rule to which the policymaker is committed:

$$y = \theta + \phi + \xi \tag{4}$$

where $\xi \sim N(0,\sigma_\xi^2)$ is a random term added to the policymaker's own observation of z. Following the literature on central bank transparency (Cukierman and Meltzer, 1986b; Faust and Svensson, 2001, 2002; Geraats, 2002), opacity or imperfect transparency in public announcements corresponds to partial disclosure of the policymaker's private information and is modelled by varying the value of σ_ξ^2. If $\sigma_\xi^2 = 0$, the policymaker fully reveals its own information. The case of full opacity is captured by $\sigma_\xi^2 = \infty$, i.e., announcements made by the policymaker contain no meaningful information or the policymaker remains silent. As observed by James and Lawler (2011), assuming that the policymaker is able to commit to a disclosure rule of the type described by (4) allows a meaningful interpretation to be placed on outcomes associated with intermediate levels of precision of the public signal. An alternative approach, with a policymaker unable to commit and completely free to announce whatever it chose after its observation of z, would imply that only full and zero disclosure would be consistent with equilibrium.

Each private agent i, before deciding on his action a_i, observes y and its own idiosyncratic noisy signal of θ:

$$x_i = \theta + \varepsilon_i, \tag{5}$$

which cannot be observed by any other agent. The noise term $\varepsilon_i \sim N(0,\sigma_\varepsilon^2)$ is uncorrelated with ε_j that affects the private signal of other agents. It follows that $\mathrm{E}(\varepsilon_i,\varepsilon_j) = 0$, $\forall j \neq i$,

and $\int_0^1 \varepsilon_i di = 0$. Moreover, all random variables, i.e., ε_i, θ, ω, ϕ and ξ, are mutually uncorrelated.

Prior to choosing a_i, agent i can neither observe g nor any a_j, $\forall j \neq i$, while the policymaker cannot observe any a_i before setting policy action. Under this assumption, agent i forms expectations of any variable conditional only on the information set consisting of the pair (y, x_i) that captures all the information available to agent i at the time of decision, while the expectations of the policymaker are conditional only on z.

Using the properties of θ, y and x_i, we obtain agent i's the best linear unbiased estimator of θ:

$$\mathrm{E}_i(\theta) = \frac{\sigma_\varepsilon^2 y + (\sigma_\phi^2 + \sigma_\xi^2) x_i}{\sigma_\varepsilon^2 + \sigma_\phi^2 + \sigma_\xi^2}. \tag{6}$$

The value of the signal z observed by the policymaker is also important for agent i's optimal decision. Therefore, agent i optimally combines y and x_i to improve the estimate of z compared to the case where only the public signal is used alone. Agent i's best linear unbiased estimator of z is given by:

$$\mathrm{E}_i(z) = \frac{(\sigma_\varepsilon^2 + \sigma_\phi^2) y + \sigma_\xi^2 x_i}{\sigma_\varepsilon^2 + \sigma_\phi^2 + \sigma_\xi^2}. \tag{7}$$

Maximising the payoff function (1) yields the optimal action of agent i:

$$a_i = (1-r)[\mathrm{E}_i(\theta) + \mathrm{E}_i(g)] + r\mathrm{E}_i(\bar{a}), \tag{8}$$

where $\bar{a} = \int_0^1 a_j dj$ denotes the average action.

3. Equilibrium solutions

Our interest in this section lies in determining how the presence of a multiplicative disturbance in the policy transmission mechanism affects the optimal stabilisation policy rule to which the policymaker is committed. The model is solved by studying each agent's action taking the value of the rule parameter ρ and the quality of the public signal as given, before determining the optimal value of ρ as a function of σ_ξ^2 and σ_ω^2.

3.1. *Optimal actions of the private sector*

Unable to observe the action of any other agent prior to making his own decision, an agent *i*'s action is postulated to be a linear function of his own private signal and public signal such that

$$a_i = \kappa_1 x_i + \kappa_2 y \,. \tag{9}$$

Since $\int_0^1 \varepsilon_i di = 0$, the average action expected by agent i is obtained as

$$\mathrm{E}_i(\bar{a}) = \kappa_1 \mathrm{E}_i(\theta) + \kappa_2 y \,. \tag{10}$$

Substituting $\mathrm{E}_i(\theta)$ from (6) and $\mathrm{E}_i(\bar{a})$ given by (10), together with $\mathrm{E}_i(g)$ obtained using (2), into (8), and then eliminating $\mathrm{E}_i(z)$ using (7), we obtain an equation representing agent *i*'s optimal action as a function of public and private signals. By substituting the conjectured solution (9) into this equation, we find the undetermined coefficients:

$$\kappa_1 = \frac{(1-r)[(1+\rho)\sigma_\xi^2 + \sigma_\phi^2]}{\sigma_\varepsilon^2 + (1-r)(\sigma_\phi^2 + \sigma_\xi^2)}, \tag{11}$$

$$\kappa_2 = \frac{(1+\rho)\sigma_\varepsilon^2 + (1-r)\rho\sigma_\phi^2}{\sigma_\varepsilon^2 + (1-r)(\sigma_\phi^2 + \sigma_\xi^2)}. \tag{12}$$

It follows straightforwardly from (11)-(12) that $\kappa_1 + \kappa_2 = 1 + \rho$. Substituting the values of κ_1 and κ_2 into (9) yields agent *i*'s equilibrium action:

$$a_i = \frac{[(1+\rho)\sigma_\varepsilon^2 + (1-r)\rho\sigma_\phi^2]y + (1-r)[\sigma_\phi^2 + (1+\rho)\sigma_\xi^2]x_i}{\sigma_\varepsilon^2 + (1-r)(\sigma_\phi^2 + \sigma_\xi^2)}. \tag{13}$$

The solution (13) is the same as in James and Lawler (2011), meaning that an agent's action is not affected by the multiplicative uncertainty in the transmission of policy intervention. Without knowing with precision the effect of policy action, the best action of private agents is based on its average effect. If $\rho = 0$, (13) is identical to the corresponding expression in Morris and Shin (2002).

3.2. *Optimal policy intervention*

The policymaker sets the value of ρ to maximise social welfare. Substituting a_i given by (9) into (1), then aggregating and taking expectations while using $\kappa_1 + \kappa_2 = 1 + \rho$, we obtain the social welfare function:

$$\mathrm{E}(W|\theta) \equiv \frac{1}{(1-r)}\mathrm{E}[\int_0^1 u_i di] = -[\kappa_1^2\sigma_\varepsilon^2 + (\kappa_2 - \rho)^2\sigma_\phi^2 + \kappa_2^2\sigma_\xi^2 + \rho^2\sigma_\omega^2\sigma_\theta^2 + \rho^2\sigma_\omega^2\sigma_\phi^2]. \quad (14)$$

It emerges from (14) that aggregation eliminates the beauty contest term, reflecting the fact that the average of expectations of all agents equals the average expectation of the private sector. The presence of σ_ω^2 in (14), which distinguishes our model from that of James and Lawler (2011), captures the impact of multiplicative uncertainty on the effect of policy intervention. The welfare effect of multiplicative uncertainty depends on uncertainty about the true state of the economy (σ_θ^2) and the precision of public signal (σ_ϕ^2). Substituting for κ_1 and κ_2 into the first-order condition for the optimal decision of the policymaker who sets ρ to maximise (14) leads to:

$$\rho^* = \frac{-[\sigma_\varepsilon^2 + (1-r)^2(\sigma_\phi^2 + \sigma_\xi^2)]\sigma_\varepsilon^2\sigma_\xi^2}{[\sigma_\varepsilon^2 + (1-r)\sigma_\phi^2]^2\sigma_\xi^2 + (1-r)^2(\sigma_\varepsilon^2 + \sigma_\phi^2)\sigma_\xi^4 + \sigma_\omega^2(\sigma_\theta^2 + \sigma_\phi^2)[\sigma_\varepsilon^2 + (1-r)(\sigma_\phi^2 + \sigma_\xi^2)]^2}. \quad (15)$$

The distinguished feature of the optimal solution given by (15) resides in that ρ^* depends on σ_ω^2 and σ_θ^2 . This features disappears if we set $\sigma_\omega^2 = 0$, leading to the solution obtained by James and Lawler (2011). Notice that, James and Lawler obtain $-1 < \rho^* < 0$ outside the special cases with perfect information available to policymaker or the private sector, i.e. $\sigma_\phi^2 = 0$ or $\sigma_\varepsilon^2 = 0$. In our model, due to the presence of σ_ω^2 and σ_θ^2, ρ^* is in the in the interval $]-\Theta, 0[$ when $\sigma_\varepsilon^2 \neq 0$ and $\sigma_\phi^2 \neq 0$, with

$$\Theta \equiv \frac{[\sigma_\varepsilon^2 + (1-r)^2\sigma_\xi^2]\sigma_\varepsilon^2\sigma_\xi^2}{[\sigma_\varepsilon^2 + (1-r)^2\sigma_\xi^2]\sigma_\varepsilon^2\sigma_\xi^2 + \sigma_\omega^2\sigma_\theta^2[\sigma_\varepsilon^2 + (1-r)\sigma_\xi^2]^2} << 1.$$

Unlike what happens in James and Lawler (2011), perfect information for the policymaker ($\sigma_\phi^2 = 0$) in combination with full transparency in public information disclosure ($\sigma_\xi^2 = 0$) implies that ρ^* is equal to zero instead of minus one.

It is to underline that an increase in σ_ω^2 reduces the absolute value of ρ^* . Thus, conforming to Brainard's conservatism principle, multiplicative uncertainty reduces the

policy activism, weakening hence James and Lawler's argument in favour of opacity about the policymaker's private information.

The optimal policy response ρ^* given by (15) indicates that for any observed non-zero value of z, the policymaker appropriately adjusts its instrument setting to counterbalance the effect of shock θ on individual and social welfare. However, due to multiplicative uncertainty, the optimal policy response ρ^* is smaller than what is necessary to sufficiently neutralise the effect of θ on individual and collective welfare. Increasing opacity will not always allow reducing the inefficiency resulted from the coordination among private agents, limiting thus the incentive for the policymaker to not fully disclose its private information.

4. The optimal degree of disclosure under multiplicative uncertainty

Taking into account the effects of multiplicative uncertainty, we now examine the welfare implications of an increased precision of the public signal provided by the policymaker.

Substituting the expressions for κ_1, κ_2 and ρ^* into (14) yields the expected welfare:

$$E(W|\theta)\big|_{\rho=\rho^*} = -\frac{\sigma_\varepsilon^2[\sigma_\varepsilon^2+(1-r)^2(\sigma_\phi^2+\sigma_\xi^2)][\sigma_\xi^2\sigma_\phi^2+\sigma_\omega^2(\sigma_\phi^2+\sigma_\xi^2)(\sigma_\theta^2+\sigma_\phi^2)]}{[\sigma_\varepsilon^2+(1-r)\sigma_\phi^2]^2\sigma_\xi^2+(1-r)^2(\sigma_\varepsilon^2+\sigma_\phi^2)\sigma_\xi^4+\sigma_\omega^2(\sigma_\theta^2+\sigma_\phi^2)[\sigma_\varepsilon^2+(1-r)(\sigma_\phi^2+\sigma_\xi^2)]^2}. \quad (16)$$

Figures 1 and 2 illustrate how the precision of public information and multiplicity uncertainty affect social welfare for two different degrees of coordination among private agents.

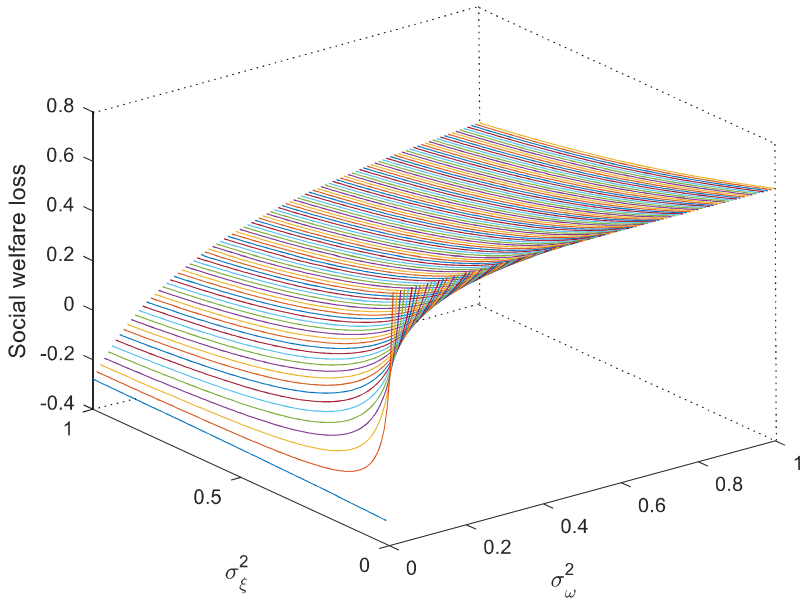

Figure 1: Social welfare loss for $r = 0.2$, $\sigma_\varepsilon^2 = 0.5$, $\sigma_\phi^2 = 0.5$ and $\sigma_\theta^2 = 1$.

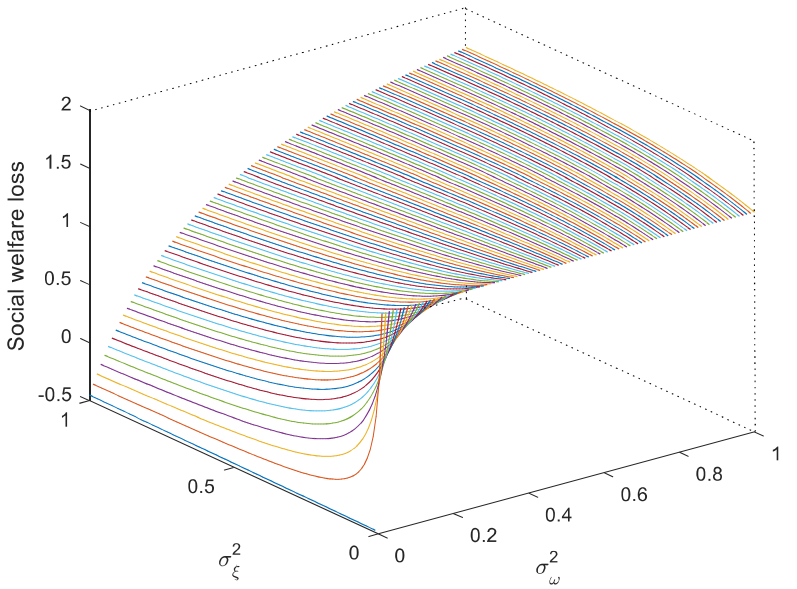

Figure 2: Social welfare loss for $r = 0.8$, $\sigma_\varepsilon^2 = 0.5$, $\sigma_\phi^2 = 0.5$ and $\sigma_\theta^2 = 1$.

4.1 The marginal effect of an increase in opacity

To evaluate how the welfare effect of the quality of the public signal is altered by multiplicative uncertainty pertained to policy intervention, we differentiate the expected welfare given by (16) with respect to σ_ξ^2 and σ_ω^2:

$$\frac{\partial E(W|\theta)\big|_{\rho=\rho^*}}{\partial \sigma_\xi^2} = \frac{\sigma_\varepsilon^4 \begin{bmatrix} r(1-r)\sigma_\phi^2\sigma_\xi^2 + (1-r)(\sigma_\theta^2+\sigma_\phi^2)\sigma_\xi^2\sigma_\omega^2 \\ +(\sigma_\theta^2+\sigma_\phi^2)[\sigma_\varepsilon^2+(1-r)\sigma_\phi^2]\sigma_\omega^2 \end{bmatrix} \times \begin{bmatrix} r(1-r)\sigma_\phi^2\sigma_\xi^2 - (\sigma_\theta^2+\sigma_\phi^2)(\sigma_\varepsilon^2+\sigma_\phi^2+\sigma_\xi^2)\sigma_\omega^2 \\ -r(2r-3)(\sigma_\phi^2+\sigma_\theta^2)(\sigma_\phi^2+\sigma_\xi^2)\sigma_\omega^2 \end{bmatrix}}{\{\sigma_\xi^2[\sigma_\varepsilon^2+(1-r)\sigma_\phi^2]^2+(1-r)^2(\sigma_\varepsilon^2+\sigma_\phi^2)\sigma_\xi^4+\sigma_\omega^2(\sigma_\theta^2+\sigma_\phi^2)[\sigma_\varepsilon^2+(1-r)(\sigma_\phi^2+\sigma_\xi^2)]^2\}^2}, \tag{17}$$

$$\frac{\partial E(W|\theta)\big|_{\rho=\rho^*}}{\partial \sigma_\omega^2} = \frac{-\sigma_\xi^4\sigma_\varepsilon^4(\sigma_\theta^2+\sigma_\phi^2)[\sigma_\varepsilon^2+(1-r)^2(\sigma_\phi^2+\sigma_\xi^2)][\sigma_\varepsilon^2+(1-r)(\sigma_\phi^2+\sigma_\xi^2)]}{\{[\sigma_\varepsilon^2+(1-r)\sigma_\phi^2]^2\sigma_\xi^2+(1-r)^2(\sigma_\varepsilon^2+\sigma_\phi^2)\sigma_\xi^4+\sigma_\omega^2(\sigma_\theta^2+\sigma_\phi^2)[\sigma_\varepsilon^2+(1-r)(\sigma_\phi^2+\sigma_\xi^2)]^2\}^2}. \tag{18}$$

In the absence of multiplicative uncertainty, i.e., $\sigma_\omega^2 = 0$, we obtain from (17) the result of James and Lawler (2011):

$$\left.\frac{\partial E(W|\theta)\big|_{\rho=\rho^*}}{\partial \sigma_\xi^2}\right|_{\sigma_\omega^2=0} = \frac{r^2(1-r)^2\sigma_\varepsilon^4\sigma_\phi^4}{\{[\sigma_\varepsilon^2+(1-r)\sigma_\phi^2]^2+(1-r)^2(\sigma_\varepsilon^2+\sigma_\phi^2)\sigma_\xi^2\}^2}. \tag{19}$$

For $\sigma_\omega^2 = 0$, $\sigma_\varepsilon^2 > 0$ and $\sigma_\phi^2 > 0$, an increase in σ_ξ^2 induces always an increase in $E(W|\theta)$. In other words, without multiplicative uncertainty, increased precision of public information is unambiguously detrimental to social welfare in both a local and global sense. In this case, the introduction of activist policy by James and Lawler (2011) substantially strengthens Morris and Shin's (2002) key findings regarding the potentially damaging effects of better public information.

Equation (18) indicates that an increase in multiplicative uncertainty always induces a decrease in social welfare that is more or less important depending on precision of public information. Thus, the presence of multiplicative uncertainty changes the incentive of the policymaker in his choice of degree of transparency.

Incentive to deviate from the equilibrium with full transparency

We examine the equilibrium solution where the policymaker is perfectly transparent, so that $\sigma_\xi^2 = 0$. Substituting $\sigma_\xi^2 = 0$ into (17), we obtain

$$\left.\frac{\partial E(W|\theta)\big|_{\rho=\rho^*}}{\partial \sigma_\xi^2}\right|_{\sigma_\xi^2=0} = -\frac{\sigma_\varepsilon^4[\sigma_\varepsilon^2+(1-2r)(1-r)\sigma_\phi^2]}{[\sigma_\varepsilon^2+(1-r)\sigma_\phi^2]^3}. \tag{20}$$

Despite the absence in (20) of a term representing multiplicative uncertainty, we observe that the latter alters the marginal effect of a decrease in transparency at the initial equilibrium with full transparency. More precisely, an increase in opacity would generally reduce social welfare. In comparison, the result obtained by James and Lawler (2010) in the absence of multiplicative uncertainty is:

$$\left.\frac{\partial E(W|\theta)\big|_{\rho=\rho^*}}{\partial \sigma_\xi^2}\right|_{\sigma_\xi^2=0} = \frac{r^2(1-r)^2\sigma_\phi^4\sigma_\varepsilon^4}{[\sigma_\varepsilon^2+(1-r)\sigma_\phi^2]^4} > 0, \tag{21}$$

which means that, in the absence of multiplicative uncertainty, it would be always preferable for the policymaker to deviate from an initial equilibrium with full transparency.

Proposition 1. *Departing from an initial equilibrium with perfect transparency, multiplicative uncertainty in the transmission of activist policy implies that the policymaker has no incentive to deviate from an initial situation of full transparency if* $r < \frac{1}{2}$ *or if* $r > \frac{1}{2}$ *and* $\sigma_\varepsilon^2 > (2r-1)(1-r)\sigma_\phi^2$.

Proof. It straightforwardly follows from examining the sign of the numerator on the right hand of (20). ■

Proposition 1 stipulates that if the weight assigned to the beauty contest term in private agents' loss function is sufficiently low, i.e., $r < \frac{1}{2}$, a fully transparent policymaker, subject to uncertain effects of its activist policy, has no incentive to be opaque independently of the relative quality of public and private information. In fact, under opacity, activist policy has a positive effect on social welfare through reducing the inefficiency in the coordination among private agents and a negative effect due to multiplicative uncertainty. At a low level of r (i.e., lower motive for coordination), the negative effect would dominate the positive one so that opacity is not desirable.

If the weight assigned to the beauty contest motive is sufficiently high, i.e., $r > \frac{1}{2}$, the policymaker will have the same attitude if the quality of the private signal is not good enough in the sense that $\sigma_\varepsilon^2 > (2r-1)(1-r)\sigma_\phi^2$. Consider the maximum of $(2r-1)(1-r)$, we can write a condition that is more strict than the previous condition is $\frac{\sigma_\varepsilon^2}{\sigma_\phi^2} > \frac{1}{8}$. The latter

means that private information should not be eight times more precise than public information. Nevertheless, for $r > \frac{1}{2}$, there is a case for opacity when the quality of public information is sufficiently low compared to private information such that $\sigma_\varepsilon^2 < (2r-1)(1-r)\sigma_\phi^2$.

Figure 3 illustrates the joint impact on social welfare of the weight assigned to beauty contest motive and the degree of transparency in the disclosure of public information.

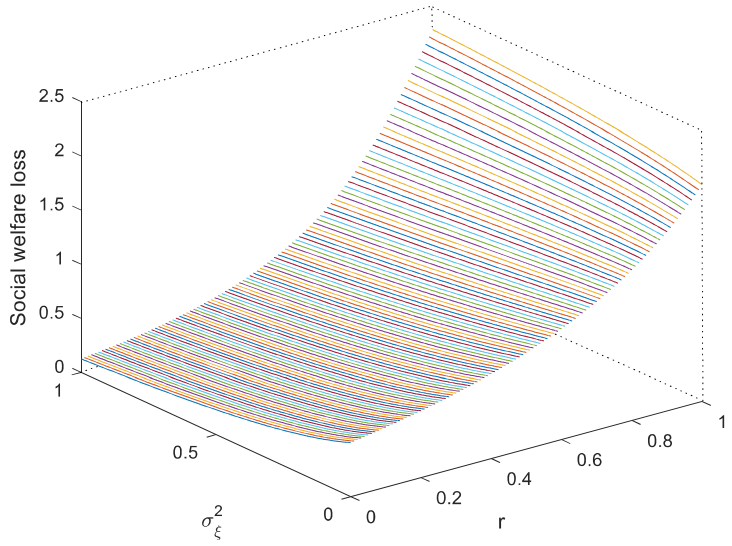

Figure 3. The social welfare loss for $\sigma_\varepsilon^2 = 0.5$, $\sigma_\phi^2 = 0.5$, $\sigma_\omega^2 = 0.5$ and $\sigma_\theta^2 = 1$.

Incentive to deviate from the equilibrium with partial transparency

Consider now the initial equilibrium where the policymaker is partially transparent, i.e., $\sigma_\xi^2 > 0$. Examining (17) leads to following propositions.

Proposition 2a. *When the transmission of activist policy is subject to multiplicative uncertainty, the policymaker has incentive to decrease opacity in the disclosure of public information if the weight assigned to the beauty contest motive is sufficiently low, i.e.* $r < \frac{(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2}{2(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2+\sigma_\phi^2} \equiv \Gamma$.

Proof. According to (17), we have $\frac{\partial E(W|\theta)\big|_{\rho=\rho^*}}{\partial\sigma_\xi^2}<0$ if

$$r(1-r)\sigma_\phi^2\sigma_\xi^2-(\sigma_\theta^2+\sigma_\phi^2)(\sigma_\xi^2+\sigma_\phi^2+\sigma_\varepsilon^2)\sigma_\omega^2-[r(2r-3)\sigma_\phi^2+r(2r-3)\sigma_\theta^2](\sigma_\xi^2+\sigma_\phi^2)\sigma_\omega^2<0.$$

Rearranging the terms in the above inequality leads to

$$(1-r)\{r[\sigma_\phi^2+2(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2]-(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2\}\sigma_\xi^2<(\sigma_\theta^2+\sigma_\phi^2)[(1-2r)(1-r)\sigma_\phi^2+\sigma_\varepsilon^2]\sigma_\omega^2. \quad (22)$$

For $r<\frac{(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2}{2(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2+\sigma_\phi^2}\equiv\Gamma<\frac{1}{2}$ and $\sigma_\xi^2>0$, condition (22) is always verified because the left hand and the right hand of (22) are negative and positive respectively. ■

Proposition 2a implies that, for a relatively small weight assigned to the beauty contest motive, whatever the initial degree of policymaker's opacity, a reduction of opacity will improve social welfare in the presence of multiplicative uncertainty. Since the policymaker has always incentive to reduce the degree of opacity, full transparency is the optimal solution. For the equilibrium where the policymaker is not fully transparent, the result found in Proposition 1 is still valid if the weight assigned to the beauty contest motive is sufficiently low. However, the condition for transparency to improve social welfare, i.e., $r<\frac{(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2}{2(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2+\sigma_\phi^2}\equiv\Gamma<\frac{1}{2}$, becomes more restrictive compared to those in Proposition 1, i.e., $r<\frac{1}{2}$ for $\sigma_\phi^2>0$.

If $\sigma_\omega^2\to 0$, we have $\Gamma\to 0$. In this case, the result reported in Proposition 2a disappears and that of James and Lawler (2011), according to which full opacity is always optimal, is again verified. The scope for which our result applies largely depends on the importance of multiplicative uncertainty σ_ω^2.

Denote $\Omega\equiv\frac{[(1-2r)(1-r)\sigma_\phi^2+\sigma_\varepsilon^2](\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2}{(1-r)[r(\sigma_\phi^2+2(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2)-(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2]}$, $\lambda_1\equiv\frac{3-\sqrt{1-8(\sigma_\varepsilon^2/\sigma_\phi^2)}}{4}$ and $\lambda_2\equiv\frac{3+\sqrt{1-8(\sigma_\varepsilon^2/\sigma_\phi^2)}}{4}$.

Examining the case where $r>\Gamma$ leads to the following proposition.

Proposition 2b. *When the transmission of activist policy is subject to multiplicative uncertainty, in the case where the weight assigned to the beauty contest motive is sufficiently high, i.e., $r>\Gamma$, the policymaker has incentive to increase transparency if he is not*

excessively opaque initially, i.e., $\sigma_\xi^2 < \Omega$, *and the private information set is sufficiently imprecise compared to the public one, i.e.,* $\frac{\sigma_\varepsilon^2}{\sigma_\phi^2} > \frac{1}{8}$.

Proof. For $r > \Gamma$, the left hand of (21) is positive. It follows that to ensure $\frac{\partial E(W|\theta)\big|_{\rho=\rho^*}}{\partial \sigma_\xi^2} < 0$, we must have $\sigma_\xi^2 < \Omega \equiv \frac{[(1-2r)(1-r)\sigma_\phi^2+\sigma_\varepsilon^2](\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2}{(1-r)\{r[\sigma_\phi^2+2(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2]-(\sigma_\theta^2+\sigma_\phi^2)\sigma_\omega^2\}}$. For this condition to make sense, Ω should be positive. For $r > \Gamma$, the denominator of Ω is positive. The numerator of Ω is positive either if $(1-2r)(1-r)\sigma_\phi^2 + \sigma_\varepsilon^2 > 0$. The latter can be written as $(r-\lambda_1)(r-\lambda_2) > 0$, where λ_1 and λ_2 denote the two solutions for r satisfying the equality $(1-2r)(1-r)\sigma_\phi^2 + \sigma_\varepsilon^2 = 0$. In the case where $\frac{\sigma_\varepsilon^2}{\sigma_\phi^2} > \frac{1}{8}$, it is straightforward to check that we have always $(r-\lambda_1)(r-\lambda_2) > 0$. ■

Proposition 2b suggests that there is also a case for the policymaker to be more transparent in the presence of multiplicative uncertainty even if the weight assigned to the beauty contest motive is relatively high, i.e. $r > \Gamma$. Under the latter condition and if the initial degree of opacity is not too high, *i.e.,* $\sigma_\xi^2 < \Omega$, an increase in opacity will decrease social welfare when private information is sufficiently imprecise compared to public information, i.e. $\frac{\sigma_\varepsilon^2}{\sigma_\phi^2} > \frac{1}{8}$.

Condition $\frac{\sigma_\varepsilon^2}{\sigma_\phi^2} > \frac{1}{8}$ is not really restrictive because it could be verified even if the quality of the public signal (i.e., $\frac{1}{\sigma_\phi^2}$) represents more than one eighth of the quality of the private signal (i.e., $\frac{1}{\sigma_\varepsilon^2}$). Both signals are about the aggregate state of the economy, θ, and need important resources for collecting, processing, and analysing data. As argued by Svensson (2006), given that central banks allocate many more resources to generate its own signal than any private agent, it seems extremely unlikely that the amount of noise in central-bank information should be more than eight times that in the private information of an individual agent, i.e. $\frac{\sigma_\varepsilon^2}{\sigma_\phi^2} < \frac{1}{8}$. This observation is supported by Christina D. Romer and David H. Romer

(2000) showing that Federal Reserve Board forecasts are more accurate than private-sector forecasts. It means that for the case where $r > \Gamma$, the policymaker generally has incentive to reduce opacity when the policymaker is not initially too opaque, i.e. $\sigma_\xi^2 < \Omega$.[5]

Notice that the lower σ_ω^2 and/or the higher σ_ϕ^2 are, the lower Γ becomes. In the limit case where $\sigma_\omega^2 = 0$, i.e., the absence of multiplicative uncertainty, we obtain $\Gamma = 0$. Hence, the condition $r < \Gamma$ in Proposition 2a becomes $r < 0$, implying that there is not anymore a case for transparency because r should always be positive. In other words, we will again obtain the results of James and Lawler.

4.2 The optimal choice of the degree of transparency

Taking account of the results reported in Propositions 2a and 2b, and using (16) to compute $E(W|\theta)\big|_{\rho=\rho^*}$ for $\sigma_\xi^2 = 0$ and $\sigma_\xi^2 = +\infty$, we consider the optimal choice of the degree of transparency in public information disclosure. This leads to the following proposition.

Proposition 3. *When the transmission of activist policy is subject to multiplicative uncertainty, if the weight assigned to the beauty contest motive is such that, i.e.,* $r < \frac{1}{2}(1+\frac{\sigma_\varepsilon^2}{\sigma_\phi^2})$, *the optimal social welfare is obtained for full transparency (opacity) if the degree of multiplicative uncertainty is relatively high, i.e.* $\sigma_\omega^2 > \frac{r^2\sigma_\phi^4}{[\sigma_\varepsilon^2+(1-2r)\sigma_\phi^2](\sigma_\theta^2+\sigma_\phi^2)}$ *(low, i.e.* $\sigma_\omega^2 < \frac{r^2\sigma_\phi^2\sigma_\phi^2}{[\sigma_\varepsilon^2+(1-2r)\sigma_\phi^2](\sigma_\theta^2+\sigma_\phi^2)}$ *, respectively). If the weight is sufficiently high, i.e.,* $\frac{1}{2}(1+\frac{\sigma_\varepsilon^2}{\sigma_\phi^2}) < r < 1$ *, social welfare is maximised for full opacity and is equal to* $E(W|\theta)\big|_{\rho=\rho^*,\sigma_\xi^2=+\infty} = -\frac{[\sigma_\phi^2+\sigma_\omega^2(\sigma_\theta^2+\sigma_\phi^2)]\sigma_\varepsilon^2}{\sigma_\varepsilon^2+\sigma_\phi^2+\sigma_\omega^2(\sigma_\theta^2+\sigma_\phi^2)}$.

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[5] We can show that even for the case where private information is extremely precise, i.e. $\frac{\sigma_\varepsilon^2}{\sigma_\phi^2} < \frac{1}{8}$, the policymaker could have incentive to be more transparent if $\max(\lambda_1, \Gamma) < r < \lambda_2$.

Proof. The proof of Proposition 2a shows that the social welfare function is always decreasing in σ_ξ^2 if $r<\Gamma$. The proof of Proposition 2b indicates that if $r>\Gamma$, the social welfare function is increasing or decreasing in σ_ξ^2 according to the value of $\sigma_\varepsilon^2/\sigma_\phi^2$. This implies that the optimal solution is obtained for either $\sigma_\xi^2=0$ or $\sigma_\xi^2=+\infty$. Using (16) to compute $E(W|\theta)\big|_{\rho=\rho^*,\sigma_\xi^2=0}$ and $E(W|\theta)\big|_{\rho=\rho^*,\sigma_\xi^2=+\infty}$, we find that the first is greater than the second if $\Phi\equiv r^2\sigma_\phi^4+[(2r-1)\sigma_\phi^2-\sigma_\varepsilon^2]\sigma_\omega^2(\sigma_\theta^2+\sigma_\phi^2)<0$. When $r<\frac{1}{2}(1+\frac{\sigma_\varepsilon^2}{\sigma_\phi^2})$, we have $\Phi<0$ only if $\sigma_\omega^2>\frac{r^2\sigma_\phi^2\sigma_\phi^2}{[\sigma_\varepsilon^2+(1-2r)\sigma_\phi^2](\sigma_\theta^2+\sigma_\phi^2)}$ and *vice versa.* In the case where $\frac{1}{2}(1+\frac{\sigma_\varepsilon^2}{\sigma_\phi^2})<r<1$, we have always $\Phi>0$, $\forall\sigma_\omega^2$. ■

By establishing that the optimal social welfare could be obtained for full transparency, Proposition 3 shows that the results obtained by James and Lawler (2011) in favour of full opacity are only valid for low degrees of multiplicative uncertainty or in the case of high beauty contest motive.

Moreover, the condition imposed on the beauty contest motive, i.e., $r<\frac{1}{2}(1+\frac{\sigma_\varepsilon^2}{\sigma_\phi^2})$, suggests that the case for full transparency could cover all degrees of beauty contest motive if the private signal is not more precise than the public signal, i.e. $\sigma_\varepsilon^2\geq\sigma_\phi^2$, implying that the condition $r<\frac{1}{2}(1+\frac{\sigma_\varepsilon^2}{\sigma_\phi^2})$ becomes $r\leq 1$.

5. Discussion

The finding that multiplicative uncertainty in the transmission of policy intervention increases the benefits of central bank transparency is due to interactions of several features that characterise the previous model.

The first feature is the strategic complementarity, in the sense of Cooper and John (1988), associated with the beauty contest term in each agent's payoff function introduced

by Morris and Shin (2002). This is the key factor that, in the absence of policy intervention, underlies their anti-transparency result. Indeed, this complementarity is at the origin of the inefficiency that characterises the equilibrium strategy of agents who observe both private and public signals. This inefficiency is reflected by the fact that the socially under-optimal equilibrium does not fully internalise the externality associated with individual action choices by private agents observing the public signal. These agents tend to place excessive weight on public information. This gives rise to the possibility that an improvement in the quality of public information might decrease social welfare.

It is to notice that strategic complementarity *per se* is neither necessary nor sufficient to generate this result. Instead, what is crucial is the relationship between the 'equilibrium degree of coordination' and the 'socially optimal degree of coordination' according to Angeletos and Pavan (2007a,b). More precisely, the beauty contest term generates an incentive for each agent to attempt to coordinate his or her actions with those of others even though such coordination yields no social benefit. These agents place excessive weight on public information because the latter provides a better estimate of the actions of other agents than idiosyncratic private information, implying that the equilibrium degree of coordination (equal to the weight placed on the beauty contest term, i.e., r) exceeds the socially optimal degree of coordination (zero). As Angeletos and Pavan demonstrate, the nature of this inefficiency is such that, greater precision of public information could potentially reinforce its detrimental impact on social welfare in a way to outweigh the direct beneficial effect associated with greater accuracy of expectations.

The second feature corresponds to the optimal policy intervention formulated by James and Lawler (2011). With this feature and in the absence of multiplicative uncertainty, the model implies that zero disclosure of public information is not only desirable, but it also allows achievement of the best possible outcome. The latter would be achieved if all private agents could be induced to respond to private and public signals in a socially efficient manner. Within the original framework of Morris and Shin, private agents place an excessively large weight on any public signal while their own private signals are not given sufficient notice. In James and Lawler (2011), the policymaker, via a reduction in the quality of the public signal, is able to induce private agents to place a greater relative weight on their own information. Thus, the policymaker is able to ensure the efficient exploitation of all

available valuable information in the form of its own private signal by adjusting the setting of its policy instrument in response to the latter. In the limit case, as the public signal contains no any valuable information, it will not play any role in determining private sector actions.

Finally, the feature that we have introduced in the present paper, i.e. multiplicative uncertainty in the transmission of policy intervention, allows us to challenge the anti-transparency results obtained by James and Lawler (2011). In accordance with Brainard's conservatism principle, multiplicative uncertainty reduces the incentive for policy activism, weakening hence the argument of James and Lawler in favour of opacity about the private information of the policymaker. Indeed, an increase in σ_ω^2 reduces the absolute value of ρ^* in (15). However, high weights assigned to the beauty contest term could induce a coordination effect that over-compensates the effect of multiplicative uncertainty and hence preserves the need of imperfect disclosure if the degree of multiplicative uncertainty is low and/or the quality of private signal ($\frac{1}{\sigma_\varepsilon^2}$) is substantially higher than that of public signal ($\frac{1}{\sigma_\phi^2}$).

To show that our conclusions have more general implications, we consider an example of a more general class of functions associated with strategic complementarity or substitutability:

$$u_i = -\left[a_i - (1-r)(\theta + g) - r\bar{a}\right]^2. \tag{23}$$

In the absence of an explicit beauty contest term in (23), the dependence of the payoff to agent i on the choices made by other agents does not reflect an extrinsic psychological or economic motive to 'do as others do' but intrinsic structural linkages in the economy. This formulation is directly comparable with that of Morris and Shin and has different implications regarding the equilibrium and socially optimal degrees of coordination. The behaviour underlying (23) could be justified in macroeconomic models that explicitly consider price and wage setting in a way that the aggregate value of agents' actions impacts on some important variable (e.g., the price level) considered by individual agents in their optimal decisions (e.g., James and Lawler 2008 and Hahn 2014).

Excluding the beauty contest term, the payoff function (23) exhibits a strategic complementarity similar to the one present in (1). To the difference of (1), the nature of the complementarity in (23) implies that the equilibrium degree of coordination is lower than the socially optimal degree of coordination. Hence, greater precision of public information is invariably beneficial in the absence of policy intervention (i.e., $g \equiv 0$) in contrast to Morris and Shin. Despite welfare improving effects of better disclosure of public information, the payoff function (23) leads to an equilibrium characterised by an inefficient use of available private information. This inefficiency could be corrected by activist policy combined with zero disclosure, which is conceived in a way to ensure that all information is optimally exploited. Notwithstanding the different implications of these two payoff functions, in the presence of optimally designed policy intervention, zero transparency always maximises welfare (James and Lawler, 2011 and 2012a, b).

When the policy intervention is characterised by multiplicative uncertainty as described by (2), any public interventions will generate some supplementary macroeconomic volatility that exponentially increases with the value of the policy rule parameter, reducing therefore the benefits of both public interventions and opacity.

Using the payoff function (23) while keeping the rest of the model unchanged, we derive the optimal value of the policy rule parameter as follows:

$$\rho^* = \frac{-(\sigma_\varepsilon^2 + \sigma_\phi^2 + \sigma_\xi^2)\sigma_\varepsilon^2\sigma_\xi^2}{[\sigma_\varepsilon^2 + (1-r)\sigma_\phi^2]^2\sigma_\xi^2 + [\sigma_\varepsilon^2 + (1-r)^2\sigma_\phi^2]\sigma_\xi^4 + \sigma_\omega^2(\sigma_\theta^2 + \sigma_\phi^2)[\sigma_\varepsilon^2 + (1-r)(\sigma_\phi^2 + \sigma_\xi^2)]^2}. \quad (24)$$

This allows rewriting the social loss function obtained by aggregating payoff function (23) across individual agents as:

$$E(W|\theta)\big|_{\rho=\rho^*} = -\frac{(1-r)^2(\sigma_\varepsilon^2 + \sigma_\phi^2 + \sigma_\xi^2)[\sigma_\xi^2\sigma_\phi^2 + \sigma_\omega^2(\sigma_\phi^2 + \sigma_\xi^2)(\sigma_\theta^2 + \sigma_\phi^2)]\sigma_\varepsilon^2}{[\sigma_\varepsilon^2 + (1-r)\sigma_\phi^2]^2\sigma_\xi^2 + [\sigma_\varepsilon^2 + (1-r)^2\sigma_\phi^2]\sigma_\xi^4 + \sigma_\omega^2(\sigma_\theta^2 + \sigma_\phi^2)[\sigma_\varepsilon^2 + (1-r)(\sigma_\phi^2 + \sigma_\xi^2)]^2}. \quad (25)$$

Comparing (15) and (16) respectively with (24) and (25) puts into evidence a great similarity between these two sets of solutions. This suggests that our previous conclusions regarding the desirability of transparency when the beneficial effects of policy interventions are impaired by multiplicative uncertainty would still prevail and are robust with respect to changes in model specifications.

6. Conclusion

Recent contributions to the debate on the desirability of transparency about the central bank's private information emphasise the role it plays in the conduct of stabilisation policy. One important finding holds that such a role reinforces the argument in favour of opacity because greater precision in the information content of the monetary policymaker's announcements is detrimental to welfare. This finding is valid as long as the transmission mechanism is known with certainty or is only affected by additive uncertainty.

Taking into account of multiplicative uncertainty, this paper arrives at a more nuanced picture regarding the desirability of perfect public information disclosure in the presence of policy activism. It is demonstrated that when policy is conducted according to an optimally-designed rule, the aforementioned finding in favour of opacity is valid only when the degree of multiplicative uncertainty is low and it would be preferable for the policymaker to be transparent otherwise. This is in accordance with Brainard's conservatism principle, i.e., multiplicative uncertainty reduces the incentive for policy activism and weakens hence the argument in favour of imperfect disclosure of the policymaker's private information in the presence of activist policy.

Our study shows that if the weight assigned to the beauty contest motive is sufficiently low, the optimal social welfare is obtained for full transparency. High weights assigned to the beauty contest motive induce a coordination effect that could over-compensate the effect of multiplicative uncertainty and hence preserves the need for imperfect disclosure to achieve optimal social welfare. This could also be true when the degree of multiplicative uncertainty is low and/or the quality of private signal is largely higher than that of public signal.

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