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Fiscal disciplining effect of central bank opacity: Stackelberg versus Nash equilibrium

Meixing Dai
BETA, University of Strasbourg, France

Moïse Sidiropoulos
LEAP, Aristotle University of Thessaloniki, Greece; BETA, University of Strasbourg, France

Abstract

Several recent studies have shown that, when fiscal and monetary authorities play a Stackelberg game, central bank opacity has a fiscal disciplining effect in the sense that it induces the government to reduce taxes and public expenditures, leading hence to lower inflation and output distortions, and in general a lower macroeconomic variability. We show in this paper that, in a Nash equilibrium, the government is still disciplined by central bank opacity. However, the disciplining effect on the level and variability of inflation and the output gap is more likely dominated by the direct effect of opacity.

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Contact: Meixing Dai - dai@unistra.fr, Moïse Sidiropoulos - sidiro@unistra.fr.
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1. Introduction

Central bank transparency is usually studied in a game framework focusing on the interactions between the monetary authority and the private sector.[1] Departing from this approach, several studies introduce monetary and fiscal policy interactions. Assuming that the government plays against the central bank as a Stackelberg leader, Ciccarone *et al*. (2007), and Hefeker and Zimmer (2011) have shown that uncertainty (or opacity) about the central bank's "political" preference parameter could have a fiscal disciplining effect, inducing lower taxes and hence lower inflation and output distortions. It could also reduce the macroeconomic volatility if the initial degree of opacity is sufficiently high. In a framework where productivity-enhancing public investment could improve future growth potential, Dai and Sidiropoulos (2011) have reexamined the issue of central bank transparency in the Stackelberg equilibrium. They have shown that, when the public investment is highly productivity enhancing, the optimal choice of tax rate and public investment eliminates the effects of distortionary taxation and fully counterbalances both the direct and fiscal-disciplining effects of opacity, on the level and variability of inflation and the output gap. By considering the above sequential timing, these authors agree with the view that the Stackelberg equilibrium concept is the one that better captures fiscal and monetary policy interactions (Beetsma and Bovenberg 1998, and Beetsma and Uhlig 1999).

However, important monetary and fiscal policy decisions could also occur simultaneously. For instance, one could notice that during severe recessions and/or financial crises – such as the current one – the timing of monetary and fiscal policies may well diverge from that of a Stackelberg game between monetary and fiscal authorities. Under these circumstances, it may be reasonable to assume that monetary and fiscal policies are chosen at the same moment. This explains why many authors have considered the implications of non-coordinated monetary and fiscal policy interactions in a Nash game (e.g., Alesina and Tabellini 1987, Beetsma and Bovenberg 1997, Dixit and Lambertini 2003, Di Bartolomeo *et al*. 2009, and Di Bartolomeo and Giuli 2011).

Hughes Hallett and Viegi (2003) have considered the implications of central bank transparency in a Nash game between fiscal and monetary authorities, both concerned with taxes. The fiscal disciplining effect is somewhat present in their model but is not highlighted by the authors. Moreover, in opposite to the above studies on the fiscal disciplining effect in the Stackelberg equilibrium, they consider that uncertainty is only associated with the weight attached to the output gap. This might induce arbitrary economic effects of central bank preference uncertainty (Beetsma and Jensen 2003) because a small change in the uncertainty specification (i.e., putting the stochastic parameter in the front of one of the two arguments of the central bank's objective function) can lead to radically different effects.

This paper contributes to the literature on central bank transparency by clarifying the issue of fiscal disciplining effect in a Nash equilibrium using a framework similar to Ciccarone *et al*. (2007) and Hefeker and Zimmer (2011), with uncertainty affecting both weights allotted to the output and inflation stabilization. The objective of the paper is to show how a change in the game structure could affect the importance of fiscal disciplining effect of central bank opacity.

[1] Following the seminal work of Cukierman and Metzler (1986), 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) among others. See Geraats (2002), and Eijffinger and van der Cruijsen (2010) for a survey of the literature.

The reminder of the paper is organized as follows. The next section presents the model. Section 3 presents the Stackelberg equilibrium. Section 4 examines the effect of opacity in the Nash equilibrium. The last section summarizes our findings.

2. The model

We consider a representative competitive firm which chooses labor to maximize profits by taking as given the prices (or the inflation rate π), the wages (and so expected inflation π^e) and tax rate (τ) on the firm's revenue, subject to a production technology. The normalized supply function incorporating the effects of distortionary taxes is:

$$x = \pi - \pi^e - \tau \,, \tag{1}$$

where x (in log terms) represents the output gap. Equation (1) is a Lucas's supply function extended by Alesina and Tabellini (1987) to take account of distortionary taxes on the output. We notice that τ allows covering a whole range of structural reforms, such as non-wage costs associated with social security (or job protection legislation), the pressures caused by tax or wage competition on a regional basis or the more general effects of supply-side deregulation (Demertzis *et al*. 2004).

The fiscal authority is concerned with the stabilization of inflation and output-gap fluctuations around a zero target and the stabilization of public expenditures g (expressed as a percentage of the output) around a target $\overline{g}$. Its loss function is

$$L^G = \tfrac{1}{2}\mathrm{E}[\delta_1 \pi^2 + x^2 + \delta_2 (g - \overline{g})^2] \,, \tag{2}$$

where E is an operator of mathematical expectations, δ_1 and δ_2 the weights assigned to the stabilization of inflation and public expenditures respectively. The weight assigned to the output-gap stabilization is unity. The public expenditures are composed of public sector consumption, i.e. public sector wages, current public spending on goods and other government spending. They are assumed to yield immediate utility to the government and have no incidence on the output supply. The government minimizes (2) subject to the budget constraint excluding seigniorage revenue and public debt:

$$g = \tau \,. \tag{3}$$

Retaining the control of fiscal instruments, the government delegates the conduct of monetary policy to the central bank. The latter sets its policy to minimize the loss function

$$L^{CB} = \tfrac{1}{2}\mathrm{E}[(\mu - \varepsilon)\pi^2 + (1+\varepsilon)x^2] \,, \qquad \mu > 0 \,, \tag{4}$$

where μ is the expected relative weight that the central bank assigns to the inflation stabilization and it could be different from δ_1. Larger (small) values of μ signify that the central bank is relatively *conservative* (*liberal* or *populist*) in the sense of Rogoff (1985).

The central bank does not make full disclosure about the weights assigned to the inflation and output-gap stabilization, meaning that ε is a stochastic variable for the government and the private sector. The distribution of ε is characterized by $\mathrm{E}(\varepsilon) = 0$, $\mathrm{var}(\varepsilon) = \mathrm{E}(\varepsilon^2) = \sigma_\varepsilon^2$ and $\varepsilon \in [-1, \mu]$. A higher variance σ_ε^2 represents a higher degree of central bank political opacity. The case where the central bank is completely predictable and hence completely transparent is represented by $\sigma_\varepsilon^2 = 0$. Given that $\mathrm{E}(\varepsilon) = 0$ and $\varepsilon \in [-1, \mu]$, σ_ε^2 has an upper bound so that $\sigma_\varepsilon^2 \in [0, \mu]$ (Ciccarone *et al*. 2007).

3. The Stackelberg equilibrium

To put into evidence the fiscal disciplining effect in the Nash equilibrium compared with that in the Stackelberg equilibrium, we summarize in this section the benchmark model of Hefeker and Zimmer (2011).

The timing of the game is the following. First, the private sector forms inflation expectations, π^e, then the government sets fiscal policy, τ, and lastly the central bank makes monetary policy decision, π. The private sector, composed of atomistic agents, plays a Nash game against the central bank. The government plays against the central bank as a Stackelberg leader.

The game is solved backwards. The minimization of (4) subject to (1) leads to the central bank's reaction function:

$$\pi = \frac{(1+\varepsilon)(\pi^e + \tau)}{1+\mu}. \tag{5}$$

The budget constraint (3) implies that the government has only one free instrument to choose between τ and g. Assume that the government uses τ as policy instrument and sets it to minimize (2), subject to (1) and (5). This leads, given that $\mathrm{E}[\frac{(\varepsilon-\mu)^2+\delta_1(1+\varepsilon)^2}{(1+\mu)^2}] = \frac{\mu^2+\delta_1}{(1+\mu)^2} + \frac{(1+\delta_1)}{(1+\mu)^2}\sigma_\varepsilon^2$, to the government's reaction function:

$$\tau = \frac{\delta_2(\mu+1)^2\bar{g} - [(\mu^2+\delta_1) + (1+\delta_1)\sigma_\varepsilon^2]\pi^e}{\mu^2+\delta_1+(1+\delta_1)\sigma_\varepsilon^2+\delta_2(1+\mu)^2}. \tag{6}$$

Substituting τ given by (6) into (5) and imposing rational expectations yield:

$$\pi^e = \frac{\delta_2(1+\mu)\bar{g}}{\delta_2\mu(1+\mu)+\mu^2+\delta_1+(1+\delta_1)\sigma_\varepsilon^2}. \tag{7}$$

Using (1), (3) and (5)-(7), we solve for π, x, τ, g, and the variance of π and x at the Stackelberg equilibrium denoted by an upper index "*S*":

$$\pi^S = \frac{(1+\varepsilon)\delta_2(1+\mu)\bar{g}}{\delta_2\mu(1+\mu)+\mu^2+\delta_1+(1+\delta_1)\sigma_\varepsilon^2}, \tag{8}$$

$$x^S = \frac{(\varepsilon-\mu)(1+\mu)\delta_2\bar{g}}{\delta_2\mu(1+\mu)+\mu^2+\delta_1+(1+\delta_1)\sigma_\varepsilon^2}, \tag{9}$$

$$\tau^S = g^S = \frac{\delta_2\mu(1+\mu)\bar{g}}{\delta_2\mu(1+\mu)+\mu^2+\delta_1+(1+\delta_1)\sigma_\varepsilon^2}, \tag{10}$$

$$\mathrm{var}(\pi^S) = \mathrm{var}(x^S) = \frac{[\delta_2(1+\mu)\bar{g}]^2\sigma_\varepsilon^2}{[\delta_2\mu(1+\mu)+\mu^2+\delta_1+(1+\delta_1)\sigma_\varepsilon^2]^2}. \tag{11}$$

The denominator of (8)-(11) increases with σ_ε^2, the numerator of (8)-(10) is invariant with σ_ε^2 while the numerator of (11) increases with σ_ε^2. Thus, an increase in σ_ε^2 reduces π^S, τ^S and g^S, leading to higher x^S (lower output distortions) since $(\varepsilon-\mu)<0$. In effect, output distortions due to taxes destined to finance public expenditures imply higher expected and current inflation, and lower output gap. The government perceives that marginal costs associated with higher taxes are higher when the central bank is more opaque. Brainard's (1967) conservatism principle will guide the government to adopt a less aggressive fiscal policy ("disciplining effect"). This stance of fiscal policy leads to lower inflation and higher output gap at the cost of larger deviation of public expenditures from their target.

Opacity triggers two opposing effects on macroeconomic volatility. The fiscal disciplining effect of opacity, by lowering τ^S, g^S and π^S (and increasing x^S), implies lower $\mathrm{var}(\pi^S)$ and $\mathrm{var}(x^S)$. It acts on the common denominator of (8)-(11). The direct effect of opacity reflects the impact of the realization of ε on inflation and the output gap. The shock ε enters in the numerator of (8)-(9), implying that σ_ε^2 affects the numerator of (11). The direct and fiscal disciplining effects of opacity on macroeconomic variability are respectively defined by the derivative of $\mathrm{var}(\pi^S)$ with respect to σ_ε^2 present in the numerator and the denominator of (11):

$$\frac{\partial\,\mathrm{var}(\pi^S)}{\partial\sigma_\varepsilon^2}=\frac{\partial\,\mathrm{var}(x^S)}{\partial\sigma_\varepsilon^2}=\overbrace{\frac{[\delta_2(1+\mu)\bar{g}]^2}{[\delta_2\mu(1+\mu)+\mu^2+\delta_1+(1+\delta_1)\sigma_\varepsilon^2]^2}}^{\text{The direct effect of opacity}}-\overbrace{\frac{[\delta_2(1+\mu)\bar{g}]^2\sigma_\varepsilon^2(1+\delta_1)}{[\delta_2\mu(1+\mu)+\mu^2+\delta_1+(1+\delta_1)\sigma_\varepsilon^2]^3}}^{\text{The fiscal disciplining effect of opacity}}.$$

The fiscal disciplining effect can more than counterbalance the direct effect of opacity on the variability of inflation and the output gap if the initial degree of opacity is sufficiently high, i.e. $\sigma_\varepsilon^2>\frac{\delta_2\mu(1+\mu)+\mu^2+\delta_1}{1+\delta_1}$ and *vice versa* (Hefeker and Zimmer 2010). The fiscal disciplining effect is more likely to induce a decrease in the macroeconomic volatility if the central bank is less averse to inflation (i.e., smaller μ) and the government less concerned with the public expenditures deviations (i.e., smaller δ_2). In mathematical terms, given the upper bound on σ_ε^2 (i.e., $\sigma_\varepsilon^2<\mu$), the previous lower bound on σ_ε^2 is valid only when $\frac{(\mu^2+\delta_1)+\delta_2\mu(1+\mu)}{(1+\delta_1)}<\mu$, implying that $\delta_2<\frac{(1+\delta_1)\mu-(\mu^2+\delta_1)}{\mu(1+\mu)}$. If the latter conditions are reversed, the direct effect of opacity will always dominate the fiscal disciplining effect (Dai and Sidiropoulos 2011).

4. The Nash equilibrium

The previous findings are based on the Stackelberg game between fiscal and monetary authorities. Such a game is justified if the government sets its fiscal policy once at the beginning of a period and the central bank makes monetary policy decisions during the period. However, important monetary and fiscal policy decisions could also occur simultaneously as we can observe in the current global financial and economic crisis. Allowing the fiscal and monetary authorities to move simultaneously in a Nash game, we can examine how a modification in the timing of the strategic game could affect the effects of opacity.

For simplicity, we retain the balanced-budget assumption for the Nash game. We remark that, according to Hefeker and Zimmer (2011), the balanced-budget assumption can be justified when the scope is a long- to medium-term analysis. However, in a short-term Nash game, this assumption can be justified on the ground that the monetary authority is independent of the fiscal authority (limiting hence the money financing of the public deficit) and the latter could be limited by a fiscal rule or debt ceiling which makes the bond financing of the public deficit unlikely.[2]

[2] An extension of the model to take account of bond and money financing of the public deficit could be indeed very interesting. The presence of public debt and seigniorage revenue could considerably complicate the results by introducing the dynamics due to the accumulation of public debt and the interaction between the effects of opacity on

The timing of the game is the following. First, the private sector forms π^e, then simultaneously, the government sets τ and the central bank chooses π. The government and the central bank play a Nash game. The game is solved by backward induction. Rational private sector will realize that the final outcomes will emerge from a solution combining the optimal reaction functions of both fiscal and monetary authorities and the expected inflation rate that these reaction functions imply.

Minimizing (4) subject to (1) leads to the central bank's reaction function which is the same as (5). Taking π^e and π as given, the government minimizes (2) subject to (1) and (3) and behaves according to the reaction function

$$\tau = \frac{1}{1+\delta_2}(\pi - \pi^e) + \frac{\delta_2}{1+\delta_2}\bar{g}. \tag{12}$$

Solving (5) and (12) for π and τ in terms of π^e and $\bar{g}$ yields

$$\pi = \frac{(1+\varepsilon)\delta_2(\pi^e + \bar{g})}{\delta_2 + \mu(1+\delta_2) - \varepsilon}, \tag{13}$$

$$\tau = \frac{(\varepsilon - \mu)\pi^e + \delta_2(1+\mu)\bar{g}}{[\delta_2 + \mu(1+\delta_2) - \varepsilon]}. \tag{14}$$

Imposing rational expectations by taking mathematical expectations of (13), we obtain:

$$\pi^e = \frac{\Omega\delta_2}{(1-\Omega\delta_2)}\bar{g}. \tag{15}$$

where $\Omega = \mathrm{E}[\frac{1+\varepsilon}{\delta_2+\mu(1+\delta_2)-\varepsilon}]$ and $1-\Omega\delta_2 = 1-\delta_2\mathrm{E}[\frac{1+\varepsilon}{\delta_2+\mu(1+\delta_2)-\varepsilon}] = 1-\mathrm{E}[\frac{\delta_2(1+\varepsilon)}{\delta_2(1+\varepsilon)+(\mu-\varepsilon)(1+\delta_2)}] > 0$.

Using (1), (3) and (12)-(15) yields the Nash equilibrium solutions denoted by an upper index "*N*":

$$\pi^N = \frac{(1+\varepsilon)\delta_2\bar{g}}{[\delta_2 + \mu(1+\delta_2) - \varepsilon](1-\Omega\delta_2)}, \tag{16}$$

$$x^N = \frac{(\varepsilon - \mu)\delta_2}{[\delta_2 + \mu(1+\delta_2) - \varepsilon](1-\Omega\delta_2)}\bar{g}, \tag{17}$$

$$\tau^N = g^N = \frac{(1+\mu)\delta_2 - [\delta_2 + \mu(1+\delta_2) - \varepsilon]\Omega\delta_2}{[\delta_2 + \mu(1+\delta_2) - \varepsilon](1-\Omega\delta_2)}\bar{g}, \tag{18}$$

$$\mathrm{var}(\pi^N) = \frac{(1+\delta_2)^2}{\delta_2^2}\mathrm{var}(x^N) \approx \left[\frac{\delta_2\bar{g}}{(1-\Omega\delta_2)}\right]^2 \frac{(1+\mu)^2(1+\delta_2)^2}{[\delta_2+\mu(1+\delta_2)]^4}\sigma_\varepsilon^2, \tag{19}$$

where the second-order Taylor approximation is used to obtain (19). Deriving (16)-(19) with respect to σ_ε^2 gives[3]

$$\frac{\partial \pi^N}{\partial \sigma_\varepsilon^2} = \frac{(1+\varepsilon)\delta_2^2\bar{g}}{[\delta_2 + \mu(1+\delta_2) - \varepsilon](1-\Omega\delta_2)^2}\frac{\partial \Omega}{\partial \sigma_\varepsilon^2} > 0,$$

$$\frac{\partial x^N}{\partial \sigma_\varepsilon^2} = \frac{(\varepsilon-\mu)\delta_2^2\bar{g}}{[\delta_2 + \mu(1+\delta_2) - \varepsilon](1-\Omega\delta_2)^2}\frac{\partial \Omega}{\partial \sigma_\varepsilon^2} < 0,$$

seigniorage revenue and fiscal decisions. As a first approach, we want to provide some clear-cut analytical results which allow comparing the effects of opacity in Stackelberg and Nash equilibrium.

[3] We can decompose as before the direct and fiscal disciplining effects of opacity on $\mathrm{var}(\pi^N)$ and $\mathrm{var}(x^N)$.

$$\frac{\partial \tau^N}{\partial \sigma_\varepsilon^2} = \frac{(\varepsilon - \mu)\delta_2 \overline{g}}{[\delta_2 + \mu(1+\delta_2) - \varepsilon](1-\Omega\delta_2)^2} \frac{\partial \Omega}{\partial \sigma_\varepsilon^2} < 0\,,$$

$$\frac{\partial\, \mathrm{var}(\pi^N)}{\partial \sigma_\varepsilon^2} \approx \frac{(1+\delta_2)^2}{\delta_2^2} \frac{\partial\, \mathrm{var}(x^N)}{\partial \sigma_\varepsilon^2} \approx \Psi \left[\frac{\delta_2 \overline{g}}{(1-\Omega\delta_2)} \right]^2 > 0\,,\ \forall \sigma_\varepsilon^2 < \frac{\mu[\delta_2 + \mu(1+\delta_2)]^2}{\delta_2(1+\mu)}\ ;$$

where $\frac{\partial\Omega}{\partial\sigma_\varepsilon^2} = \frac{(1+\mu)(1+\delta_2)}{[\delta_2+\mu(1+\delta_2)]^3}$ and $\Psi = \frac{(1+\mu)^2(1+\delta_2)^2\{\delta_2(1+\mu)\sigma_\varepsilon^2 + \mu[\delta_2+\mu(1+\delta_2)]^2\}}{[\delta_2+\mu(1+\delta_2)]^4\{\mu[\delta_2+\mu(1+\delta_2)]^2 - \delta_2(1+\mu)\sigma_\varepsilon^2\}}$. Given the second-order Taylor approximation $\Omega = \mathrm{E}[\frac{1+\varepsilon}{\delta_2+\mu(1+\delta_2)-\varepsilon}] \approx \frac{1}{\delta_2+\mu(1+\delta_2)} + \frac{(1+\mu)(1+\delta_2)}{[\delta_2+\mu(1+\delta_2)]^3}\sigma_\varepsilon^2$, the following condition $\sigma_\varepsilon^2 < \frac{\mu[\delta_2+\mu(1+\delta_2)]^2}{\delta_2(1+\mu)}$ is imposed to ensure the coherence of the approximation with the fact that $1-\Omega\delta_2 > 0$. Given the upper bound on σ_ε^2 (i.e., $\sigma_\varepsilon^2 < \mu$), the above condition ensuring $\frac{\partial\, \mathrm{var}(\pi^N)}{\partial\sigma_\varepsilon^2} > 0$ must be rewritten as $\forall \sigma_\varepsilon^2 < \min\left\{\mu; \frac{\mu[\delta_2+\mu(1+\delta_2)]^2}{\delta_2(1+\mu)}\right\}$.

Higher opacity induces higher π^N and lower x^N (higher output distortions). It affects negatively τ^N. The fiscal disciplining effect is present in the Nash equilibrium and induces a lower τ^N, while being unable to counterbalance the direct effect of opacity on π^N and x^N.

Our algebraic results show that, under the second-order Taylor approximation, the variances of inflation and the output gap are positively affected by an increase in the degree of opacity given that the initial degree of opacity is capped by two upper limits. As long as we admit the validity of the second-order Taylor approximation, we can say that, contrary to the Stackelberg equilibrium, the fiscal disciplining effect cannot counterbalance the direct effect of opacity on the volatility of inflation and the output gap.

The above findings could be explained by the absence of any commitment made by the government in the Nash game. Its non-cooperative behavior will lead the central bank to doubt if opacity has any fiscal disciplining effect on the government's decisions. Thus, the government will not have incentive to restrict as less as possible public expenditures and taxes. In other words, Brainard's (1967) conservatism principle which implies that the government is incited to adopt a less aggressive fiscal policy in the case of central bank opacity is not likely to play an important role in guiding the government's actions in the Nash equilibrium even though the perceived marginal costs associated with higher taxes are higher. Therefore, as the fiscal disciplining effect is likely unimportant, the direct effect of opacity will dominate.

We remark that in the Nash equilibrium, the situation where $\frac{\mu[\delta_2+\mu(1+\delta_2)]^2}{\delta_2(1+\mu)} < \sigma_\varepsilon^2 < \mu$ is excluded in order to ensure the coherence of the second-order Taylor approximation with the fact that $1-\Omega\delta_2 > 0$, while in the Stackelberg equilibrium, the fiscal disciplining effect can more than counterbalance the direct effect of opacity on the variability of inflation and the output gap if the initial degree of opacity is such that $\frac{\delta_2\mu(1+\mu)+\mu^2+\delta_1}{1+\delta_1} < \sigma_\varepsilon^2 < \mu$.

The fiscal disciplining is dominated by the direct effect of opacity only if the initial degree of opacity is sufficiently small, i.e., $\sigma_\varepsilon^2 < \frac{\mu[\delta_2+\mu(1+\delta_2)]^2}{\delta_2(1+\mu)} \equiv \Theta_1$ in the Nash equilibrium, and $\sigma_\varepsilon^2 < \frac{\delta_2\mu(1+\mu)+\mu^2+\delta_1}{1+\delta_1} \equiv \Theta_2$ in the Stackelberg equilibrium. After some simple algebra, we find that

$\Theta_1-\Theta_2=\mu^2[\delta_2+\mu(1+\delta_2)]+f(\delta_2)\delta_1$, where $f(\delta_2)\equiv[\delta_2(1+\mu)+\mu][\delta_2(1+\mu)+\mu]\mu-\delta_2(1+\mu)$ is a convex function. It is straightforwardly to show that $f(\delta_2)>0$, $\forall\mu>\frac{1}{2}$. Therefore, if the central bank assigns an average weight sufficiently high to the inflation stabilization, i.e. $\mu>\frac{1}{2}$, we have $\Theta_1>\Theta_2$. In this case, it can be said that in the Nash game the fiscal disciplining effect is less likely to counterbalance the direct effect given that $\sigma_\varepsilon^2<\mu$. For $\mu<\frac{1}{2}$, this proposition could also be true if the weight assigned by the government to the stabilization of public expenditures is either sufficiently low, i.e. $\delta_2<\frac{(1-2\mu^2)-\sqrt{(1-4\mu^2)}}{2(1+\mu)}$, or sufficiently high, i.e. $\delta_2>\frac{(1-2\mu^2)+\sqrt{(1-4\mu^2)}}{2(1+\mu)}$. However, this proposition will be reversed if we simultaneously have $\mu<\frac{1}{2}$, $\delta_2\in]\frac{(1-2\mu^2)-\sqrt{(1-4\mu^2)}}{2(1+\mu)};\frac{(1-2\mu^2)+\sqrt{(1-4\mu^2)}}{2(1+\mu)}[$, and $\delta_1<\frac{-\mu^2[\delta_2+\mu(1+\delta_2)]}{f(\delta_2)}$. The condition imposed on δ_1 implies that the weight assigned to the inflation stabilization must be sufficiently low given the values of δ_2 and μ.

5. Conclusion

In this paper, we have shown that the fiscal disciplining effect of central bank opacity, which can significantly affect the macroeconomic performance and volatility in the framework where the government and the central bank act respectively as Stackelberg leader and follower, could become insignificant when these two authorities play a Nash game. In the Nash equilibrium, an increase in the degree of central bank opacity will always induce a higher inflation, a lower output gap and in general a higher macroeconomic volatility, despite the existence of fiscal disciplining effect. Given the upper limits on the initial degree of opacity, the fiscal disciplining effect is less likely to counterbalance the direct effect on macroeconomic volatility in the Nash equilibrium than in the Stackelberg equilibrium, except when the central bank and the government both care insufficiently about the inflation stabilization, and the weight assigned by the government to the stabilization of public expenditures is at intermediate levels.

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