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

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2011

Fiscal disciplining effect of central bank opacity:

Stackelberg *versus* Nash equilibrium

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Abstract: In a Stackelberg equilibrium, 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. This effect could disappear or be dominated by the direct effect of opacity when the fiscal and monetary authorities play a Nash game.

Keywords: Distortionary taxes, output distortions, central bank transparency (opacity), fiscal disciplining effect.

JEL classification numbers: E52, E58, E62, E63, H30.

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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. Departing from this approach, several studies introduce monetary and fiscal interactions. Assuming that the government (leader) and the central bank play a Stackelberg game, Ciccarone *et al*. (2007), and Hefeker and Zimmer (2010) have shown that uncertainty (or opacity) about the central bank's "political" preference parameter could have a fiscal disciplining effect, leading to lower inflation and higher output gap. It could also reduce the macroeconomic volatility if the initial degree of opacity is sufficiently high. We remark that such effect is somewhat present but not underlined in Hughes Hallett and Viegi (2003) who consider a Nash game between fiscal and monetary authorities, both concerned with taxes. In opposite to the two other studies, the latter considers 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). In effect, a small change in the uncertainty specification (e.g., 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.

In this paper, we reconsider the issue of fiscal disciplining effect in a Nash equilibrium using a framework similar to Ciccarone *et al*. (2007) and Hefeker and Zimmer (2010), 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.

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 central bank 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:

$$x = \pi - \pi^e - \tau, \qquad (1)$$

where x (in log terms) represents the output gap.

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

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

where E is an operator of mathematical expectations, δ_1 and δ_2 are 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

The timing of the game is the following. First, the private sector forms 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 (3), 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:

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

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

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

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

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

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

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

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

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 can more than counterbalance the direct effect of opacity on the variability of inflation and 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* (see 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 is 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.

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. 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.

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 private sector still plays a Nash game against the central bank. The government and the central bank play a Nash game against each other.

The game is solved by backward induction. Rational private sector will realize that the final outcomes will emerge from a solution which combines 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 hence behaves according to the reaction function

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

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

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

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

$$\pi^e = \frac{\Omega\delta_2}{(1-\Omega\delta_2)}\bar{g}\,. \tag{14}$$

where $\Omega = \mathrm{E}_t[\frac{1+\varepsilon}{\delta_2+\mu(1+\delta_2)-\varepsilon}] \approx \frac{1}{\delta_2+\mu(1+\delta_2)} + \frac{(1+\mu)(1+\delta_2)}{[\delta_2+\mu(1+\delta_2)]^3}\sigma_\varepsilon^2$ is a second-order Taylor approximation.

Using (1) and (12)-(14) yields the Nash equilibrium solutions denoted by an upper index "N":

$$\pi^N = \frac{(1+\varepsilon)\delta_2\bar{g}}{[\delta_2+\mu(1+\delta_2)-\varepsilon](1-\Omega\delta_2)}, \tag{15}$$

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

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

$$\mathrm{var}(\pi^N) = \frac{(1+\delta_2)^2}{\delta_2^2}\mathrm{var}(x^N) \approx \left[\frac{\delta_2\bar{g}}{(1-\Omega\delta_2)}\right]^2 \frac{(1+\mu)^2(1+\delta_2)^2}{[\delta_2+\mu(1+\delta_2)]^4}\sigma_\varepsilon^2, \tag{18}$$

where the second-order Taylor approximation is used to obtain (18). Deriving (15)-(18) with respect to σ_ε^2 gives

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

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

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

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

where $\frac{\partial\Omega}{\partial\sigma_\varepsilon^2} = \frac{(1+\mu)(1+\delta_2)}{[\delta_2+\mu(1+\delta_2)]^3}$ and $\Psi = \frac{(1+\mu)^2(1+\delta_2)^2\{\delta_2(1+\mu)\sigma_\varepsilon^2+\mu[\delta_2+\mu(1+\delta_2)]^2\}}{[\delta_2+\mu(1+\delta_2)]^4\{\mu[\delta_2+\mu(1+\delta_2)]^2-\delta_2(1+\mu)\sigma_\varepsilon^2\}}$.

Higher opacity induces higher π^N and lower x^N (higher output distortions). It affects positively τ^N if $1-\delta_2(1+\mu)+\varepsilon>0$. The latter is verified if the weight attributed to the public expenditure target is low enough (small δ_2), the central bank is sufficiently populist (smal μ) and/or the preference choc ε quite large. If $1-\delta_2(1+\mu)+\varepsilon<0$, the fiscal disciplining effect is present in the Nash equilibrium and induces a lower τ^N, while being unable to more than counterbalance the direct effect of opacity on π^N and x^N.

We remark that in (15)-(18, when $(1-\Omega\delta_2)$ tends to zero, π^N, x^N and τ^N could tend to $+\infty$ and $-\infty$ while $\mathrm{var}(\pi^N)$ and $\mathrm{var}(x^N)$ approach $+\infty$. Under full transparency, we have $(1-\Omega\delta_2)>0$ and $\pi^N>0$. Higher opacity leads to higher π^N, with the latter approaching $+\infty$ when σ_ε^2 increases in the way that $(1-\Omega\delta_2)\to 0_+$. Then, a slight increase in σ_ε^2 could turn π^N from $+\infty$ to $-\infty$. The predictions of the model just before and after that the $(1-\Omega\delta_2)$ changes sign are implausible and this could be explained by that the Taylor approximation works only with small deviations. To avoid that, we impose $(1-\Omega\delta_2)>0$, i.e. $\sigma_\varepsilon^2<\frac{\mu[\delta_2+\mu(1+\delta_2)]^2}{\delta_2(1+\mu)}$.

Since $\mathrm{var}(\pi^N)$ and $\mathrm{var}(x^N)$ are approximated around $\varepsilon=0$, the condition for the existence of fiscal disciplining effect is therefore $1-\delta_2(1+\mu)<0$, implying that $\sigma_\varepsilon^2<\mu<\frac{\mu[\delta_2(1+\mu)+\mu]^2}{\delta_2(1+\mu)}$ is always verified.[1]

Therefore, contrary to the Stackelberg equilibrium, the fiscal disciplining effect can never more than counterbalance the direct effect of opacity on the volatility of inflation and output gap.

[1] We have $\frac{\mu[\delta_2(1+\mu)+\mu]^2}{\delta_2(1+\mu)}>\mu[\delta_2(1+\mu)+\mu]>\mu$ if $\delta_2(1+\mu)>0$ and $\sigma_\varepsilon^2<\mu$ according to Cicarone *et al*. (2007).

The above findings could be explained by the absence of any commitment made by the government in the Nash game. Its non-cooperative behaviour will lead the central bank to doubt if opacity has any fiscal disciplining effect in terms of reducing the public expenditures and taxes. 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 under 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 inexistent or very weak, the direct effect of opacity will dominate.

5. Conclusion

In this paper, we have shown that the fiscal disciplining effect of central bank opacity, which manifests in the framework where the government and the central bank act respectively as Stackelberg leader and follower, could disappear or become very weak when these two authorities play a Nash game. In the Nash equilibrium, an increase in the degree of central bank opacity will always induce higher inflation rate and higher output distortions, with a higher macroeconomic volatility. It would increase the volatility of inflation and output gap even in the case where the fiscal disciplining effect is present. These results are independent of the initial degree of central bank opacity, in opposite to the Stackelberg equilibrium.

References:

Beetsma, R.M.W.J. and H. Jensen (2003), "Why money talks and wealth wispers: Monetary uncertainty and mystique. A comment," *Journal of Money, Credit, and Banking* 35, 129-36.

Brainard, W. (1967), "Uncertainty and the effectiveness of policy," *American Economic Review* 57 (2), 411-25.

Ciccarone, Giuseppe, Enrico Marchetti and Giovanni Di Bartolomeo (2007), "Unions, fiscal policy and central bank transparency," *The Manchester School*, vol. 75, 617-33.

Hefeker, Carsten and Blandine Zimmer, (2010), "Uncertainty and fiscal policy in an asymmetric monetary union," *Open Economies Review*, forthcoming.

Hughes-Hallett, A. and Viegi, N. (2003), "Imperfect transparency and the strategic use of information in monetary policy: An ever present temptation for central bankers", *The Manchester School*, 71, 498-520.

Rogoff, K. (1985), "The optimal degree of commitment to a monetary target." *Quarterly Journal of Economics* 100(4), 1169–1190.