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Cornel Oros & Blandine Zimmer

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Université de Strasbourg
Pôle Européen de Gestion et d'Economie
61 avenue de la Forêt Noire
67085 Strasbourg Cedex
http://large.em-strasbourg.eu/

IFS
Institut de Finance
de Strasbourg

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Cornel Oros* and Blandine Zimmer†

Abstract

Governments fear spending disturbances. To derive their optimal fiscal decisions, they use the *robust control* approach developed by Hansen and Sargent (2005, 2008). Results show that myopic governments, being more concerned by short-term spending imperatives than by the economy's output level, react to central bank conservatism by setting high taxes, detrimental to macroeconomic performances. Consequently, delegating monetary policy to not too a conservative central bank seems appropriate.
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1 Introduction

Uncertainty about key macroeconomic aggregates and relationships governing the economy is an important challenge for policymakers and substantially influences their choices.[1] In recent years, uncertainty seems to have become particularly challenging for fiscal policy-makers, and this, especially in the European Monetary Union (EMU) member countries. With the Eurozone debt crisis, many EMU governments have indeed experienced sharp and uncontrollable rises of their sovereign interest rates. This has not only severely

*CRIEF, University of Poitiers and LEO, University of Orléans, France. email: cornel.oros@univ-poitiers.fr

†LaRGE, University of Strasbourg, France. email: zimmer@unistra.fr

[1] A series of papers has examined the monetary policymakers' decisions in the face of uncertainty about the structural parameters of the economy. Among them, Peersman and Smets (1999), Giannoni (2002), Söderström (2002), Gros and Hefeker (2002) or Tillmann (2009a) for instance confirm Brainard's (1967) classical result which is to say that monetary authorities tend to act more carefully if they are confronted to some model uncertainty. Other papers like Stock (1999) and Onatski and Stock (2002) challenge this view and find that uncertainty may lead to more vigorous interest rate setting.

deteriorated their budget conditions by increasing public spending but has also confronted them with high uncertainty about their budget position. The euro crisis has shed some light on the fiscal policy-makers' difficulty to control their budget position. They may face uncertainty stemming from lots of factors, including bond markets pressures as well as factors due to economic, social or political instability. The analysis of the implications of the fiscal policy-makers' uncertainty on macroeconomic outcomes thus represents a crucial topic to be put into the agenda of academics and practitioners. As far as we know, only two theoretical studies have dealt with this issue. Di Bartolomeo *et al.* (2009) and Di Bartolomeo and Giuli (2011) develop a model where monetary and fiscal authorities face uncertainty about the parameters describing their policy effectiveness. They qualify Dixit and Lambertini (2003)'s result obtained under the *symbiosis assumption* by showing that, under multiplicative uncertainty, even if monetary and fiscal authorities share identical targets for output and inflation, the achievement of these targets is no longer guaranteed.

In this paper, we consider a monetary union (MU) where national governments face uncertainty about the exact amount of public spending to be financed. More precisely, when setting their fiscal policy, governments fear some spending disturbances they do not necessarily have under control and which may alter or invalidate their budget projections. In addition, we assume that their spending can only be financed by taxation.[2] To model their fiscal decision-making under this type of uncertainty, we use the *robust control* approach.[3] Through this approach, we assume that governments are unable to define any probability distribution to spending disturbances. To set an optimal tax rate under these circumstances, they seek to select a fiscal policy that is robust to the most pessimistic perspective, i.e. that remains optimal even under the worst possible outcome of spending disturbances.

We allow for some asymmetry among the MU governments in the sense that we consider that some of them have lower ability to hedge against spending shocks and are thus more vulnerable to budget uncertainty than the others. This vulnerability can be so high that they are obliged to attach priority attention to spending stabilisation. Their fiscal policy is then mainly focused on short-term spending imperatives at the expense of the economy's output performance. We qualify this type of governments as "myopic".

Obviously, the governments' spending uncertainty affects their fiscal decisions but not only. It is also likely to interfere in the central bank's decisions and even compromise the good functioning of monetary policy institutions.

[2]This is consistent with the EMU situation where governments face a balanced-budget requirement in the medium term.

[3]The robust control approach has been introduced into economic models by Hansen *et al.* (1999) and Hansen and Sargent (2005, 2008). A number of recent papers has used this approach to determine the optimal monetary policy in the case where some uncertainty is faced by central bankers (see for instance, Giannoni, 2002, 2007; Tillmann, 2009a,b, 2014, 2019, Woodford, 2010 among others).

A relevant example can be found in the EMU. The high budgetary instability that has been observed in some member countries during the sovereign debt crisis has not only affected the European Central Bank (ECB)'s decision-making but also questioned their ability to stay in the EMU and, through contagion effects, the existence of the monetary union as a whole. Debates about the necessity to reform the EMU are relevant at this point. Our paper contributes to this debate by studying how to adapt monetary institutions in response to the MU governments' budget vulnerability.

The objective of the paper is twofold. First, we seek to outline the consequences of the governments' spending uncertainty for their fiscal decisions and, through it, for macroeconomic outcomes in the MU member countries. Second, in a more normative prospect, we study the implications of this uncertainty for the optimal design of monetary institutions in the MU. In particular, we examine how the central bank's degree of conservatism should be adjusted when the member countries' governments suffer from budget uncertainty stemming from spending disturbances.

Our analysis shows that when the MU governments are vulnerable to spending disturbances, they set high tax rates. This exacerbated fiscal pressure translates into low output in the member countries, obliging the central bank to be accommodating by conducting an inflationary monetary policy. In an asymmetric MU, this result suggests that countries whose governments have higher ability to hedge against spending disturbances then their MU-partners will rapidly feel inconvenienced by the too inflationary monetary policy set by the central bank in reaction to the bad output situation in their partner countries.

The main result of the paper however concerns the normative question of the optimal design of monetary policy institutions. We show that central bank conservatism exacerbates the governments' fear of spending disturbances, i.e. the uncertainty they feel about the spending target to be financed. As a consequence, if governments are myopic, they do not hesitate to raise taxes, even if this deteriorates the economy's output condition. It finally results that in the case of highly myopic governments, the central bank's degree of conservatism should be reduced in response to the governments' lower their ability to hedge against spending disturbances.

The rest of the paper is organized as follows. In the next section, we develop a MU-model with monetary-fiscal strategic interactions in which we integrate the issue of budget uncertainty. The implications of this uncertainty for the member countries' economic outcomes are discussed in section 3. Section 4 presents the normative analysis by addressing the question of the optimal choice of central bank conservatism in the presence of governments' budget uncertainty. A final section concludes and discusses new issues for future research in the context of the EMU.

2 The model

We consider a monetary union (MU) composed of n countries (indexed by i, $\forall i = 1, ..., n$). Monetary policy is set by a common central bank (CB) whereas fiscal policies are decided at the national level by the member countries' governments.

Output x_i in country i is given by:

$$x_i = \pi - \pi^e - \tau_i \tag{1}$$

where π and π^e are the actual and expected inflation rates respectively; τ_i defines the tax rate in country i. Behind this relation lies the idea that unexpected inflation, by eroding real wages, induces firms to augment their demand for labour and thus their production. Greater taxation on the firms' revenues, on the contrary, discourages production. Hence, as is common in this literature (see Beetsma and Bovenberg, 1998, 1999 among others), fiscal policy has a negative impact on aggregate supply via taxation. We thus assume that taxation is used for consumption only and not investment, so that it has no productive effect on supply.[4]

The common CB cares about deviations of both, inflation and output from their respective targets which, for convenience, we assume to be equal to zero. Its loss function is given by:

$$L^{CB} = I\pi^2 + x^2 \tag{2}$$

where π and $x = \sum x_i/n$ respectively define the MU-wide inflation rate and the average output level in the monetary union. We here suppose that the central bank perfectly controls the MU-wide inflation rate so that its monetary policy instrument is π. Parameter I is defined as the central bank's degree of conservatism which measures the CB's relative concern for inflation with respect to output.[5]

National governments are concerned about both, the level of output and of public spending in their economy. The objectives of government in country i (henceforth, government i) are summarized as follows:

$$L_i^G = x_i^2 + \alpha \left(g_i - \tilde{g}_i\right)^2 \tag{3}$$

[4]Yet, the variable τ_i could also be interpreted as the tax rate net of public investment so as to capture the productivity enhancing role of public expenditures. See for instance Ismihan and Ozkan (2004) who explicitly consider the composition of public spending by distinguishing between public sector consumption and investment.

[5]The literature also refers to I as the CB's degree of independence. For a distinction between CB conservatism and independence, see for instance Eijffinger and Hoeberichts (1998, 2008), Hughes Hallett and Weymark (2005), Weymark (2007) and Hefeker and Zimmer (2011).

where g_i and $\tilde{g}_i$ respectively define the country i's actual and targeted levels of public expenditures as shares of output. Parameter α measures the relative importance government i gives to its spending objective.[6]

When setting its fiscal decision, government i faces the following budget constraint:

$$g_i = \tau_i \tag{4}$$

This equation corresponds to a balanced budget requirement where taxation is the only source of financing public expenditures.

Government i will thus have to tolerate some tax distortions in order to finance its positive target of public expenditures $\tilde{g}_i$. The type of expenditures that we consider here corresponds to public consumption such as salaries of public employees and other current spending generated by the supply of public goods. It also encompasses social security spending and the payment of interest on public debt (which we do not explicitly model). We here abstract from the beneficial impact public spending may have on output as g_i does not integrate public investment goods.

As it is noticeable, the spending target $\tilde{g}_i$ is specific to each country. For government i, it writes:

$$\tilde{g}_i = \overline{g} + \epsilon_i \tag{5}$$

where $\overline{g}$ represents a fixed level of public spending and is expressed as a share of output. It can be interpreted as an average socially optimal level of spending in the MU.

According to this expression, government i has its own spending target that may deviate from the average socially optimal level in the MU $\overline{g}$. Indeed, government i's spending can be affected by lots of specific disturbances such as bad business cycles developments, political and social instability – obliging the government to increase social expenditures – or financial market frictions putting pressure on public debt interest rates. These disturbances are captured by ϵ_i and render the exact amount of its spending highly uncertain for the government. To hedge against this uncertainty, government i may want to keep some leeway in its decision-making by taking account of ϵ_i in its spending target.

A crucial assumption here is that government i is unable to assign any probability distribution over alternative outcomes of ϵ_i. To determine its fiscal policy under this assumption, we use a robust control (non-Bayesian) approach which consists in setting its tax rate (and thus spending level) so that it is robust to the worst possible realization of ϵ_i.

Following Hansen and Sargent (2005, 2008), this approach can be modelled as a game between government i and a fictitious "evil agent" whose aim is to set the disturbances ϵ_i so as to maximize the government's welfare loss.

[6] For convenience, we assume that member countries governments share the same weight α as well as the same output target, which is normalized at zero.

Concretely, this implies for government i to solve the following *minmax* program:

$$\min_{\tau_i} \max_{\epsilon_i} L^G = x_i^2 + \alpha \left(g_i - \tilde{g}\right)^2 - \theta_i \epsilon_i^2 \tag{6}$$

where θ_i defines the government's ability to hedge against spending disturbances. This parameter varies in the interval $[\underline{\theta}; \infty[$.[7] The certainty case corresponds to $\theta_i \to \infty$. This is the common case in the literature where it is assumed that governments do not suffer from spending uncertainty and thus have a perfect control over their budget. Parameter θ_i is indexed by i, implying that we allow for some asymmetry among MU-member countries.

An alternative method to model fiscal uncertainty would be to use a Bayesian approach where spending disturbances correspond to white noise stochastic shocks and where fiscal uncertainty is given by the variance of these shocks. This method suggests that governments can attach priors to budget disturbances, which seems difficult in reality. In particular, in a context of high political, social or financial instability – as EMU countries for instance have experienced with the financial turmoil in 2007 and the Euro crisis afterwards – it appears reasonable to assume that governments are unable to statistically measure their budget uncertainty.

The timing of the game is as follows. First, in each member country, the private sector rationally determines inflation expectations through the nominal wage setting process. Then, simultaneously, the MU governments determine their tax rate τ_i using the robust control approach detailed above. Finally the common central bank selects π, the MU inflation rate. Since in practice monetary policy can be adjusted more quickly than fiscal policy, we assume that, when taking their decisions, governments anticipate the central bank's reaction to their decisions and thus act as Stackelberg leaders.

The game is solved by backward induction and we begin by considering the common central bank's program. Minimizing loss function (2) with respect to π and taking the member countries' aggregate supply functions (1) as given, we have:

$$\pi = \frac{\pi^e + \tau}{1 + I} \tag{7}$$

where $\tau = \sum_i \tau_i / n$ defines the average MU-wide tax rate.

With the rational expectations assumption ($\pi^e = \pi$), we obtain:

$$\pi = \frac{\tau}{I} \tag{8}$$

Solving government i's program with the robust control approach and taking rational expectations (so that, $\pi^e = \pi$), we obtain the equilibrium

[7] The lower bound $\underline{\theta}$ will be defined below in footnote 8.

level of tax rate in country i:

$$\tau_i = \frac{\alpha \overline{g} \theta_i \left(1+I\right) n}{\theta_i \left[n \left(1+I\right)\left(1+\alpha\right) - 1\right] - \alpha \left[n(1+I) - 1\right]} \tag{9}$$

Integrating this expression into the central bank's reaction (8), the output function (1) as well as the budget constraint (4) and considering rational expectations, we have the equilibrium values for output and public expenditures in country i, respectively: $x_i = -\tau_i$ and $g_i = \tau_i$, and also obtain the equilibrium expression for inflation in the MU: $\pi = \tau$ (with, as already specified, $\tau = \sum_i \tau_i / n$).[8]

In our model, the distortion from the first best outcome is due to the presence of a positive (fixed) spending target $\overline{g} > 0$, obliging the government to collect a positive amount of taxes ($\tau_i > 0$).[9] This in turn reduces output ($x_i < 0$) and forces the central bank to implement an expansionary and thus inflationary monetary policy ($\pi > 0$).

As for country i's equilibrium spending gap ($g_i - \overline{g}$), it can either be positive or negative, depending on the value of θ_i and α. For instance, when $\alpha > \theta_i$, government i pays high attention to its spending level (α high) whereas its ability to hedge against spending disturbances is relatively low (θ_i low). $\alpha > \theta_i$ also implies that $\alpha/\theta_i > 1$, which means that government i is more preoccupied by its spending disturbances (given the high importance it attaches to spending and its low ability to hedge against the disturbances) then by the economy's output level.[10] In this case, government i does not hesitate to set strong fiscal pressure in order to finance excessive expenditures even though this discourages the private sector's productive investments. Here, country i's spending gap appears to be positive.

In what follows, we qualify this type of government as *myopic*, prioritizing short-term expenditures at the expense of output. $\alpha/\theta_i > 1$ can thus be seen as the degree of government i's myopia ; the higher this ratio, the higher the government's concern for short-term spending imperatives.

3 Equilibrium outcomes

We here begin by investigating the effects of the governments' uncertainty on equilibrium outcomes. We then also consider the macroeconomic effects of monetary institutional parameters like the degree of CB conservatism and the number of MU member countries in the presence of this uncertainty.

[8] We assume that, for each government, θ_i is sufficiently high for the denominator of expression 9 to be positive. This implies: $\theta_i > \frac{\alpha[n(1+I)-1]}{n(1+I)(1+\alpha)-1} = \underline{\theta}$; $\underline{\theta}$ being the minimum value of θ in our model.

[9] The first best outcome corresponds to a situation where: $\tau_i = x_i = \pi = 0$ and $g_i = \overline{g}$.

[10] Indeed, according to the government's loss function (Eq. 6), the relative weight attached to output is equal to 1.

3.1 Effects of the governments' budget uncertainty

We define budget uncertainty as the governments' incapacity to perfectly control their spending. Formally, budget uncertainty is inversely related to θ_i: the lower θ_i, the lower the government i's ability to hedge against spending disturbances.

From expression (9), we observe that budget uncertainty exacerbates the tax distortion due to the positive spending target.[11] We obtain the following result.

Result 1. *A decrease in θ_i, the government i's ability to hedge against spending disturbances translates into:*
i) higher levels of taxation and public spending and into a lower level of output in country i.
ii) an increase in the MU-wide inflation rate π – proportionally to $1/n$ corresponding to the country's weight in the CB's decision process.

Proof: See appendix.

Indeed, when government i has low control over its spending (θ_i low), it fears large disturbances and feels obliged to set high taxes in order to collect enough fiscal revenues to compensate for these disturbances. As a consequence to this strong fiscal pressure, output in country i is depressed. This in turn induces the central bank to implement a more expansionary and thus inflationnary monetary policy, depending on the country i's weight in its decision process ($1/n$).

3.2 Effects of central bank conservatism

After having clarified the implications of the governments' spending uncertainty, we can now proceed to examine the macroeconomic effects of CB conservatism in this context.

Result 2. *An increase in the central bank's degree of conservatism I translates into :*
i) higher taxes τ_i and public spending g_i as well as into lower output x_i in the member countries where the government is myopic (i.e. is characterized by $\frac{\alpha}{\theta_i} > 1$).
ii) higher inflation in the MU if the majority of the member countries are characterized by a relatively low θ_i (i.e. $\theta_i < \theta_1$).

[11] Note that budget uncertainty disappears when $\theta_i \to \infty$, which means that government i has a perfect control over its spending. By setting $\theta_i \to \infty$, equilibrium outcomes correspond to those observed in the standard case (see for instance Hefeker and Zimmer (2011) where a similar model is used with the assumption $\theta_i \to \infty$).

Proof: See appendix.

This results states that when the member countries' governments are myopic ($\frac{\alpha}{\theta_i} > 1$), CB conservatism exerts a detrimental impact on their macroeconomic performances.

Clearly, if the CB is highly inflation averse, it accommodates national tax hikes to a lesser extent, thereby rendering them more costly in terms of reduced output. Two opposite fiscal reactions to CB conservatism are observable, depending on the governments' concern for spending disturbances relatively to their concern for output.

In the standard case where governments do not suffer from spending uncertainty ($\theta_i \to \infty$), they adapt to high CB conservatism by setting low taxes. This improves their country's output performance but it also contributes to exacerbate their spending gap. Indeed, as has been observed earlier, in the case where $\alpha/\theta_i < 1$ (and thus where $\theta_i \to \infty$), the equilibrium spending level g_i is lower than the target $\overline{g}$, so that the deviation $(g_i - \overline{g})$ is negative. By reducing the tax level, and thereby the spending level g_i, CB conservatism finally aggravates this deviation.

However, in the case where governments are exposed to budget uncertainty (θ_i has a finite value), high CB conservatism makes them feel more vulnerable to spending disturbances.[12] This in turn leads them to set higher taxes.

When governments are myopic ($\frac{\alpha}{\theta_i} > 1$), the fear of spending disturbances-effect prevails, explaining their high tax rate in response to CB conservatism and consequently, their low output level and high spending gap $(g_i - \overline{g})$.

If these member countries are in the majority, the overall impact of CB conservatism on the MU-wide tax level is positive, translating into an expansionary monetary policy (see Eq. (8)). In the case where the MU-governments' θ_i is very low, this effect may be so strong that it compensates the standard inflation-reducing effect of CB conservatism, explaining why this latter can be associated with a high level of inflation in the MU.

If this is the case, considering that society is concerned by output x_i, inflation π and public spending deviations $g_i - \overline{g}$, CB conservatism eventually proves detrimental for social welfare and this, not only in member countries where the government is myopic – as their real economic performances are deteriorated – but also in the others. Indeed, even though CB conservatism may contribute to boost production in these latter, if they attach high importance to inflation and spending deviations, CB conservatism is also welfare-reducing for them.

[12] This latter effect hinges on the observation that a higher degree of CB conservatism triggers an increase in ϵ_i, the government i's anticipation of spending disturbances. Mathematically, this writes as follows: $\frac{\partial \epsilon_i}{\partial I}$. Calculations are available upon request.

3.3 Effects of monetary union

We here investigate the implications of sharing a common monetary policy for countries whose government is vulnerable to spending disturbances.

Result 3. *Participation in a monetary union:*
i) leads to higher taxes τ_i and public spending g_i as well as to lower output x_i in countries with a myopic government ($\frac{\alpha}{\theta_i} > 1$).
ii) translates into an increase in inflation – compared to the level observed under national monetary policy – for countries whose government is less vulnerable to spending disturbances (θ_i higher) than their partners in the MU.

Proof: See appendix.

The process of monetary unification triggers similar macroeconomic effects than an increase in CB conservatism. Indeed, as can be observed from expression (8), both institutional changes (increase in n and in I) contribute to moderate the CB's accommodating response to national tax decisions. This has two implications: first, it aggravates the output-reducing impact of tax hikes and second, it exacerbates the governments' fear of spending disturbances.[13]

How governments adapt to this situation depends on whether they are more concerned by output or by their spending and spending disturbances (i.e whether α/θ_i is higher or lower than 1).

Myopic governments with $\frac{\alpha}{\theta_i} > 1$ will prefer to raise taxes and spending even though this implies a deterioration of output. Participation in the MU finally results into poorer output performance in their countries and may thereby contribute to reduce social welfare. This is the case if the society is particularly concerned by economic activity and employment.

Under these circumstances, these countries might be tempted by an exit from the union.[14]

As for the member countries whose government is not myopic (with $\frac{\alpha}{\theta_i} < 1$), even if they observe an improvement in their output performance with the MU process – this effect has already been stressed by Beetsma and Bovenberg (1998) – they may experience an increase in inflation due to the more accommodating policy the CB adopts in response to their partner countries' higher fiscal pressure. If society pays particular attention to price stability, MU may also induce a diminution of social welfare in those countries. They might then think that the solution to their problem lies

[13] This latter effect hinges on the observation that a higher number of member countries triggers an increase in ϵ_i, the government i's anticipation of spending disturbances. Mathematically, this writes as follows: $\frac{\partial \epsilon_i}{\partial n}$. Calculations are available upon request.

[14] Obviously, they would have to compare the benefit of their exit with the large and hardly quantifiable cost that this would imply.

in the option that MU-partners suffering from an excessive budget uncertainty leave the union. To avoid this option and possibly a breakdown of the union as a whole, the CB would have to adapt its policy stance as well as its institutional features. This issue is examined in section 4.

4 Optimal central bank conservatism in the presence of budget uncertainty

We here consider a social planner, representing the MU society, whose objective is to define the optimal degree of central bank conservatism I by taking account of the governments' budget uncertainty.

The social planner's loss function is given by:

$$L^S = x^2 + \varphi\pi^2 + \beta\left(g - \overline{g}\right)^2 \tag{10}$$

where φ and β respectively define the relative weight the social planner puts on inflation and public spending objective. We assume that its spending target corresponds to $\overline{g}$, the average optimal level of public spending in the MU.

The social planner is concerned by monetary union-wide aggregates. To determine their level, it considers an average degree of uncertainty for the MU-governments, which is labelled θ, as it is difficult for it to guess each individual government's degree of uncertainty, θ_i. The MU-wide aggregates taken into account by the social planner are thus obtained by replacing θ_i with θ in the expressions of equilibrium output, inflation and public spending.

Integrating these equilibrium values of output ($x(\theta)$), inflation ($\pi(\theta)$) and public spending ($g(\theta)$) into the social planner's loss function and minimizing with respect to I, the central bank's degree of conservatism, yields different results that are detailed in the following subsections.

4.1 How the optimal I depends on θ

Result 4. *When the MU governments are very myopic ($\alpha/\theta > 1$ and very high), the lower their ability θ to hedge against spending disturbances, the lower should be the degree of central bank conservatism I.*

Proof: See appendix.

To understand this outcome, we must remember result 2 stating that high CB conservatism is associated with poor macroeconomic performances – in terms of price stability and output – in the case of highly myopic governments. So, when their myopia is exacerbated (higher α/θ) due to higher vulnerability to spending disturbances (lower θ), it becomes socially optimal

to reduce the CB's degree of conservatism.

Result 5. *It is socially optimal to delegate monetary policy to a central banker who cares less about inflation than society*
i) for very high degrees of the governments' myopia (α/θ very high).
ii) also for very low degrees of the governments' myopia (low values of α/θ), when the society's aversion for public spending deviations is relatively high (β high).

Proof: See appendix.

When governments are extremely myopic (α/θ very high), the deteriorating impact of CB conservatism on macroeconomic performances can be so strong that it proves optimal to delegate monetary policy to a CB that is less conservative than society. This might also be justified when the governments' myopia (α/θ) is very low provided that the society attaches sufficient importance to public spending deviations (β high). Indeed, in this case, the optimal choice of I mainly depends on the effects of this latter on the spending gap ($g - \overline{g}$). As can be deduced from result 2, reducing the CB's degree of conservatism leads to higher public spending in countries where the government is characterized by $\alpha/\theta < 1$ and thereby helps to attenuate the spending gap.[15] Hence, if spending deviations is a sufficiently important issue in these countries, it might be optimal to reduce the CB's degree of conservatism to such an extent that it becomes inferior to that of the society.

4.2 How the optimal I should be adjusted in a MU

We here also examine how the degree of CB conservatism should be adjusted with the monetary unification (or monetary union enlargement) in this particular context where the member countries' governments suffer from budget uncertainty.[16]

Result 6. *i) Monetary unification (or MU enlargement) should be accompanied by a diminution of the CB's degree of conservatism I when the member countries' governments are either extremely myopic (α/θ very high) or not myopic at all ($\alpha/\theta < 1$). For intermediate values of the governments' myopia (α/θ), it is socially optimal to increase I with the MU process.*
ii) In the case where the society's aversion for public spending deviations is very high (β large), I should be reduced for very high degrees of the governments' myopia (α/θ very high) and increased otherwise.

[15] Here, we must remember that in countries where $\alpha/\theta < 1$, the spending level is too low so that the spending gap ($g - \overline{g}$) is negative.

[16] Note that monetary unification and monetary union enlargement can both be formalized by an increase in n, the number of member countries. More specifically, in the case of a monetary unification process n raises from $n = 1$ to $n > 1$.

Proof: See appendix.

For an intuitive account of this result, we must first explain how the MU process influences the impact that CB conservatism has on fiscal decisions and through it on economic outcomes. The standard mechanism is that monetary unification contributes to attenuate the macroeconomic impact of CB conservatism as, in a MU, monetary policy and its institutional parameters affect each individual member country's economic outcomes to a lesser extent. To say it differently, the link between the CB and national governments is distended.

Yet, when the member countries governments are extremely myopic due to a very low control over their spending (θ very low), MU exacerbates the negative macroeconomic effects of CB conservatism. Indeed, when budget uncertainty is very high, governments are strongly dependent on the CB's accommodating monetary policy as it helps to attenuate the output deteriorating consequences of excessive tax rates that must be implemented in response to their fear of spending disturbances. When the CB becomes more conservative, it reacts to output conditions to a lesser extent, thereby emphasizing the governments' vulnerability to budget uncertainty and aggravating its negative macroeconomic consequences (see result 2). The MU process reinforces this detrimental mechanism as the CB then cares even less about each individual country's output situation. Hence, monetary unification exacerbates the negative macroeconomic consequences of CB conservatism and requires thereby a diminution of its optimal value.

For more standard levels of the governments' myopia, the traditional mechanism applies: the MU process mitigates the macroeconomic effects of CB conservatism. We must here distinguish two cases depending on β, the importance that society attributes to public spending.

When this later is low, the optimal choice of CB conservatism essentially depends on its effect on price stability and output. According to result 2, these effects are detrimental for myopic governments ($\alpha/\theta > 1$) and becomes beneficial otherwise. As a consequence, for myopic governments, MU lessens the detrimental effects of CB conservatism and can thereby be accompanied by an increase in its degree. For non-myopic governments ($\alpha/\theta < 1$), however, it seems optimal to reduce the degree of CB conservatism as its beneficial macroeconomic effects are dampened by the monetary unification.

On the contrary, when β is high, the optimal choice of CB conservatism is mainly dictated by its impact on public spending deviations ($g_i - \tilde{g}$). This impact is always detrimental as an increase in I systematically exacerbates the deviation ($g_i - \tilde{g}$). Yet, the MU process alleviates this detrimental impact and the optimal degree of CB conservatism can thus be increased with the

number of MU members. When β is particularly high, this effect dominates, explaining why it can be socially optimal to accompany monetary unification by an increase in the CB's degree of conservatism even when governments are not myopic at all ($\alpha/\theta < 1$).

5 Conclusion

In this paper, we extend a simple MU-model with strategic monetary-fiscal interactions by considering the case where national governments suffer from budget uncertainty due to spending disturbances. An important element in our analysis is the governments' ability to hedge against these disturbances. Unsurprisingly, our analysis reveals that when this ability is low, governments feel obliged to set high taxes, which prove to be detrimental for their countries' macroeconomic performances.

It also appears from our analysis that the governments' fear of spending disturbances depends on the monetary institutional environment. Indeed, we show that this fear is exacerbated when the central bank is highly conservative. Myopic governments, being focused on short-term spending imperatives, thus react to central bank conservatism by increasing taxes even though this implies lower output.

Moreover, by allowing for asymmetric vulnerability of national governments to budget uncertainty, we observe that the MU process is likely to aggravate the heterogeneity of the member countries' economic situation: the most-vulnerable countries may experiment a decrease in their already-low output level whereas the least-vulnerable countries may see their output level increase. Besides, it is quite possible that these latter will have to accept higher inflation in the MU. This is the case if their partner countries are extremely vulnerable to spending disturbances, obliging the common central bank's to set a very accommodating and inflationary policy.

On the basis of these results, we investigate the normative question of the optimal degree of central bank conservatism in the presence of government budget uncertainty. Our findings reveal that when national governments are myopic, the lower their ability to hedge against spending disturbances, the lower should be the central bank's conservatism.

Concretely, our results can be related to the more general debate on the Eurozone monetary architecture that emerged in the aftermath of the euro crisis. Indeed, the two pillars of the EMU economic governance are based on the ECB's price stability objective and on the fiscal discipline constraints imposed on governments by the Stability and Growth Pact. This institutional framework implies a *de facto* clear prioritization of macroeconomic objectives, supposing that inflation stabilization is the dominant objective of public authorities and leaving little room for national objectives in terms of growth and employment. Well justified at the moment of the creation of the EMU, the EMU policy-mix organization has to adapt to the post-crisis

environment by strongly taking account of the uncertainty surrounding fiscal policy-making and the difficulties it generates for national governments to simultaneously promote economic activity and ensure budget balance. According to our findings, more central bank concern for output and employment in the member states would help to alleviate this dilemma and attenuate the pressure on national fiscal policies.

Our normative analysis investigates the optimal institutional design of the MU's central bank by focusing on its degree of conservatism. Monetary institutional parameters however do not only consist in the central bank's degree of conservatism, they also encompass its independence with respect to the national governments' considerations. In our model, we do not explicitly model the degree of central bank independence ; it is combined with the degree of conservatism.

An interesting extension of the paper would consist in disentangling both concepts: *Conservatism* would then be defined as the relative weight that the central bank assigns to inflation control in its loss function, while *independence* would refer to its ability to freely determine monetary policy according to its own priorities, without having to bother about the national governments' objectives and difficulties to reach them.

This explicit distinction between conservatism and independence would allow us to examine their socially optimal combination in the presence of governments' budget uncertainty. In the theoretical debate about the optimal institutional design of central banks, independence and conservatism are both considered to be crucial ingredients for a stable and successful monetary policy. For instance, the initial organization of the EMU economic governance relies on the idea that these parameters are complements: the ECB's institutional features have been defined so that priority is given to price stability and to ensure its large autonomy in decision-making. Yet, the ECB's decisions and behaviour since the euro crisis have brought up the thought that this kind of combination between conservatism and independence is no longer appropriate in the current environment. In particular, we believe that the ECB's large monetary financing of government debt to prevent speculative attacks and the "Whatever it takes" speech by ECB President Draghi on 26 July 2012 have somewhat challenged its *de facto* independence.[17] The ECB seems to have endorsed a new responsibility for guaranteeing financial stability in countries with high public debt levels, implying some cooperation with the concerned governments and, thereby creating political pressures that may limit its *de facto* independence. Hence, in the context where some EMU governments suffer from high budget uncertainty due in particular to their vulnerability to financial market turbulence likely to cause important sovereign interest rate hikes, conservatism and independence no longer appear to be optimal complements. Whether these parameters may even become substitutes – so that, in order to maintain its focus on inflation,

[17] See den Haan *et al.* (2017)'s discussion about the future of central bank independence.

the central bank is obliged to expand its "governments rescue" operations – could be an interesting issue for future research.

Appendix

Proof of Result 1:

i) Differentiating τ_i, the equilibrium tax rate in country i, with respect to θ_i leads to:

$$\frac{\delta\tau_i}{\delta\theta_i} = \frac{-\overline{g}\alpha^2 n(1+I)[n(1+I)-1]}{\{\theta_i\left[n\left(1+I\right)\left(1+\alpha\right)-1\right]-\alpha[n(1+I)-1]\}^2} < 0 \qquad (11)$$

Consequently, we have: $\frac{\delta g_i}{\delta\theta_i} = \frac{\delta\tau_i}{\delta\theta_i} < 0$ and $\frac{\delta x_i}{\delta\theta_i} = -\frac{\delta\tau_i}{\delta\theta_i} > 0$.

ii) By differentiating π, the equilibrium inflation rate in the MU, with respect to θ_i, we obtain: $\frac{\delta\pi}{\delta\theta_i} = \frac{1}{n}\frac{\delta\tau_i}{\delta\theta_i} < 0$.

Proof of Result 2:

i) Differentiating τ_i with respect to I leads to:
$\frac{\delta\tau_i}{\delta I} = \frac{\alpha n\tilde{g}\theta_i(\alpha-\theta_i)}{\{\theta_i[n(1+I)(1+\alpha)-1]-\alpha[n(1+I)-1]\}^2}$. This derivative is positive when $\alpha > \theta_i$.
As a result: $\frac{\delta g_i}{\delta I} = \frac{\delta\tau_i}{\delta I}$ and $\frac{\delta x_i}{\delta I} = -\frac{\delta\tau_i}{\delta I}$ are respectively positive and negative when $\alpha > \theta_i$.

ii) According to expression (8), we have: $\frac{\delta\pi}{\delta I} = \frac{\sum_i}{n}\frac{\partial(\tau_i/I)}{\partial I}$.
Differentiating $\frac{\tau_i}{I}$ with respect to I yields:
$\frac{\partial(\tau_i/I)}{\partial I} = \frac{\alpha n\theta_i\tilde{g}\left\{-\theta_i\left[n(1+I)^2(1+\alpha)-1\right]+\alpha\left[n(1+I)^2-1\right]\right\}}{\{I\theta_i[n(1+I)(1+\alpha)-1]-\alpha I[n(1+I)-1]\}^2}$. This derivative is positive for $\theta_i < \frac{\alpha\left[n(1+I)^2-1\right]}{n(1+I)^2(1+\alpha)-1} \equiv \theta_1$.[18]

Hence, if for the majority of member countries $\theta_i < \theta_1$, then $\frac{\sum_i}{n}\frac{\partial(\tau_i/I)}{\partial I}$ is positive, implying that $\frac{\delta\pi}{\delta I} >$ is positive too.

Proof of Result 3:

i) The macroeconomic effects of the monetary unification process are captured by considering the transition from the case where $n = 1$ to the case $n > 1$. These effects can thus be determined by differentiating the equilibrium expression of τ_i, g_i and x_i with respect to n. This leads to:
$\frac{\delta\tau_i}{\delta n} = \frac{\alpha\overline{g}\theta_i(1+I)(\alpha-\theta_i)}{\{\theta_i[n(1+I)(1+\alpha)-1]-\alpha[n(1+I)-1]\}^2}$. This derivative becomes positive when: $\alpha > \theta_i \Rightarrow \frac{\alpha}{\theta_i} > 1$. Consequently, $\frac{\delta g_i}{\delta n} = \frac{\delta\tau_i}{\delta n}$ and $\frac{\delta x_i}{\delta n} = -\frac{\delta\tau_i}{\delta n}$ become respectively

[18]Note that $\theta_1 > \underline{\theta}$; $\underline{\theta}$ being the minimum value of θ_i defined in footnote 8.

positive and negative for $\frac{\alpha}{\theta_i} > 1$.

ii) We know from result 1 that countries with a high θ_i display a low level of taxation. If they join a MU with partner-countries where θ_i is relatively lower and thus taxation relatively higher, they may have to accept a more inflationary monetary policy as this latter is then set by a common CB on the basis of the average tax rate in the MU (see Eq.(8)).

Proof of Result 4:

Integrating the equilibrium expressions for $x(\theta)$, $\pi(\theta)$ and $g(\theta)$ into (10), we obtain:

$$L^S = \frac{\overline{g}^2 \left\{ [\theta\alpha n (1+I)]^2 (I^2+\varphi) + \beta I^2 (\alpha-\theta)^2 [1-n(1+I)]^2 \right\}}{\left\{ \theta I [n(1+\alpha)(1+I)-1] - I\alpha [n(1+I)-1] \right\}^2} \tag{12}$$

Minimizing this loss function with respect to I, we obtain the following first order condition:

$$\frac{\partial L^S}{\partial I}(I=I^*) = \frac{2\alpha n\theta \overline{g}^2}{\left\{ \theta I [n(1+\alpha)(1+I)-1] - I\alpha [n(1+I)-1] \right\}^3} \Theta = 0 \tag{13}$$

where:

$$\begin{aligned} \Theta &= \Lambda \left\{ I^3(\alpha-\theta) + \varphi \left[\alpha \left[n(1+I)^2 - 1 \right] - \theta \left[n(1+I)^2(1+\alpha) - 1 \right] \right] \right\} \\ &+ \beta I^3 (\alpha-\theta)^2 [n(1+I)-1] \end{aligned}$$

with $\Lambda = \alpha n\theta(1+I)$.

The determination of the optimal degree of conservatism, I^*, implies to solve the equation $\frac{\partial L^S}{\partial I} = 0$. Yet, our objective in this paper is not to calculate the exact value of I^*. It is rather to study how I^* should be adjusted according to different parameters, in particular to θ. In this perspective, we determine $\frac{\partial I*}{\partial \theta}$ using the implicit function theorem.

$$\frac{\partial I^*}{\partial \theta} = \frac{-\frac{\partial \left(\frac{\partial L^S}{\partial I} \right)}{\partial \theta}}{\frac{\partial \left(\frac{\partial L^S}{\partial I} \right)}{\partial I}} \tag{14}$$

The denominator $\frac{\partial \left(\frac{\partial L^S}{\partial I} \right)}{\partial I} = \frac{\partial^2 L^S}{\partial I^2}$ being always positive for $I = I^*$ – as I^* corresponds to the value of CB conservatism that minimizes L^S – the sign of $\frac{\partial I^*}{\partial \theta}$ is given by the opposite sign of the numerator $\frac{\partial \left(\frac{\partial L^S}{\partial I} \right)}{\partial \theta}$.

By differentiating $\frac{\partial L^S}{\partial I}$ with respect to θ, we obtain:

$$\frac{\partial\left(\frac{\partial L^S}{\partial I}\right)}{\partial\theta} = \frac{2n\left(\overline{g}\alpha\right)^2}{I^3\left\{\theta\left[n\left(1+\alpha\right)\left(1+I\right)-1\right]-\alpha\left[n\left(1+I\right)-1\right]\right\}^4}\,\Omega\left(\theta\right)$$

where

$$\begin{aligned}\Omega\left(\theta\right) &= \Lambda I^3\left\{2\left[n(1+I)-1\right](\theta-\alpha)-\Lambda\right\}\\ &+ \varphi\Lambda\left\{2\left(\theta-\alpha\right)\left[n(1+I)\left[n(1+I)^2-2-I\right]+1\right]+\Lambda\left[2n(1+I)^2-3I-2\right]\right\}\\ &+ \beta I^3\left[n(1+I)-1\right]^2(\theta-\alpha)\left\{\left[n(1+I)-1\right](\alpha-\theta)+2\Lambda\right\}\end{aligned}$$

$\Omega\left(\theta\right)$ becomes negative – implying that $\frac{\partial I^*}{\partial\theta}$ is positive – for sufficiently low values of θ compared to α. Note that, for the third term of $\Omega\left(\theta\right)$, we set $\alpha > \underline{\alpha}$ so that the expression into the curly brackets is necessarily positive.[19] The third term is thus negative as soon as $\theta < \alpha$.

Figure 1 below represents function $\Omega\left(\theta\right)$ in blue ; the line in red representing $\Omega\left(\theta\right)=0$. The parameters have the following values: $\alpha=2$, $n=19$; $I=1$; $\beta=1$ and $\varphi=1$. With these values $\underline{\alpha}=0.4868421$ and $\underline{\theta}=0.6548673$, that is why we limit θ to 0.65.

Proof of Result 5:

i) We here consider the expression $\partial L^S/\partial I$, as given by Eq.(13), for the case where $I=\varphi$, that is when the CB's degree of inflation aversion coincides with the society's one. After tedious algebra, we observe that:[20]

$\frac{\partial L^S}{\partial I}\left(I=\varphi\right)$ is positive when:

$$\theta < \frac{2\alpha\beta\varphi^3[n(1+\varphi)-1]-\alpha^2 n(1+\varphi)\left\{\varphi\left[n(1+\varphi)^2-1\right]+\varphi^3-\sqrt{\Delta}\right\}}{2\beta\varphi^3[n(1+\varphi)-1]-2\alpha n(1+\varphi)\left\{\varphi\left[n(1+\varphi)^2(1+\alpha)-1\right]+\varphi^3\right\}} \equiv \theta_1$$

where $\Delta=\left[\varphi\left[n(1+\varphi)^2-1\right]+\varphi^3\right]^2+4\varphi^4\beta(1+\varphi)\left[n(1+\varphi)-1\right]$.

In this case, social loss can be attenuated by reducing I, implying that the optimal level of I is necessarily lower than φ.

ii) Moreover, for $\beta > \frac{\alpha n(1+\varphi)\left\{\varphi\left[n(1+\varphi)^2(1+\alpha)-1\right]+\varphi^3\right\}}{\varphi^3[n(1+\varphi)-1]} \equiv \beta_1$, we observe that $\frac{\partial L^S}{\partial I}\left(I=\varphi\right)$ is positive either when $\theta<\theta_1$ or when

$$\theta > \frac{2\alpha\beta\varphi^3[n(1+\varphi)-1]-\alpha^2 n(1+\varphi)\left\{\varphi\left[n(1+\varphi)^2-1\right]+\varphi^3\right\}+\sqrt{\Delta}}{2\beta\varphi^3[n(1+\varphi)-1]-2\alpha n(1+\varphi)\left\{\varphi\left[n(1+\varphi)^2(1+\alpha)-1\right]+\varphi^3\right\}} \equiv \theta_2$$

[19] For the expression into curly brackets of the third term to be positive, we must have: $\alpha\left[n(1+I)-1\right] > \theta\left\{\left[n(1+I)-1\right]-2\alpha n(1+I)\right\}$. This condition is fulfilled in particular when the expression into curly brackets of the right-hand side is negative, which is the case for: $\alpha > \frac{n(1+I)-1}{2n(1+I)} \equiv \underline{\alpha}$. So, we retain $\underline{\alpha}$ as the lower bound for α, implying that governments have a minimum of concern for their public spending objective.

[20] Calculations are available upon request.

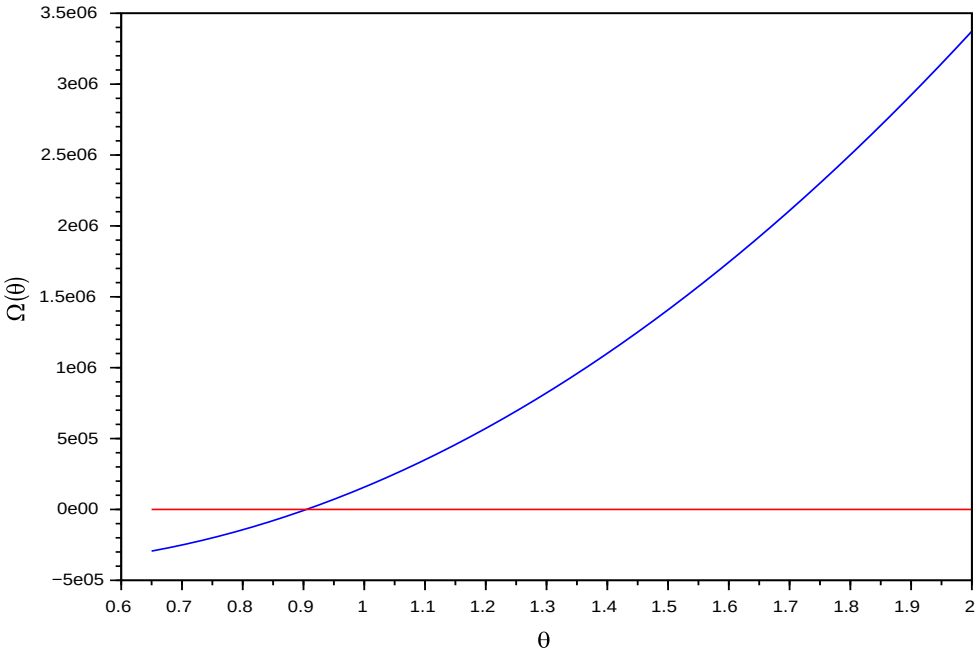

Figure 1: $\Omega(\theta)$

Consequently, when β is sufficiently large, the optimal level of I proves to be lower than φ not only for extremely low values of θ ($\theta < \theta_1$) but also for extremely high values ($\theta > \theta_2$).

Figures 2 and 3 represent (in blue) $\Theta(\theta)$ of expression $\frac{\partial L^S}{\partial I}(I = \varphi)$ in the cases where $\beta = 1$ and $\beta = 500$ respectively; the line in red representing $\Theta(\theta) = 0$. The numerical values that have been chosen for the different parameters are as follows: $\alpha = 2$, $n = 19$; $I = 1$ and $\varphi = 1$. With these values $\underline{\alpha} = 0.4868421$ and $\underline{\theta} = 0.6548673$, that is why we limit θ to 0.65.[21]

Proof of Result 6:

To study how I^* should be adjusted with the MU enlargement, we determine $\frac{\partial I^*}{\partial n}$ using the implicit function theorem.

$$\frac{\partial I^*}{\partial n} = \frac{-\frac{\partial\left(\frac{\partial L^S}{\partial I}\right)}{\partial n}}{\frac{\partial\left(\frac{\partial L^S}{\partial I}\right)}{\partial I}} \tag{15}$$

[21] For $\frac{\partial L^S}{\partial I}(I = \varphi)$ to become positive also for large values of θ, the condition $\beta > \beta_1$ must be fulfilled. By integrating numerical values into the expression of β_1, we obtain $\beta_1 = 468.32$, that is why we assume that $\beta > 500$ in figure 3.

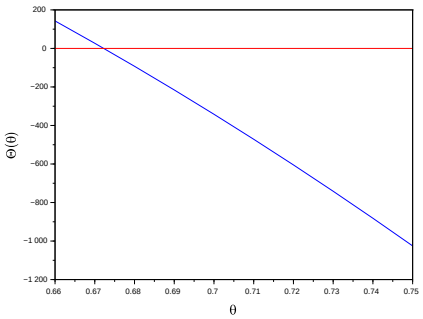

Figure 2: $\Theta(\theta)$ for $\beta = 1$

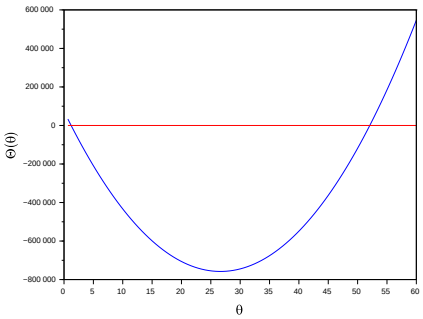

Figure 3: $\Theta(\theta)$ for $\beta = 500$

The denominator $\frac{\partial\left(\frac{\partial L^S}{\partial I}\right)}{\partial I} = \frac{\partial^2 L^S}{\partial I^2}$ being always positive for $I = I^*$, we have : $sign\left(\frac{\partial I^*}{\partial n}\right) = sign\left(\frac{-\partial\left(\frac{\partial L^S}{\partial I}\right)}{\partial n}\right)$.

By differentiating $\frac{\partial L^S}{\partial I}$ with respect to n, we obtain:

$$-\frac{\partial\left(\frac{\partial L^S}{\partial I}\right)}{\partial n} = \frac{2\bar{g}^2\alpha\theta n(1+I)}{\{\theta\left[n\left(1+I\right)\left(1+\alpha\right)-1\right]-\alpha\left[n\left(1+I\right)-1\right]\}^4}\,\Phi\left(\theta\right)$$

where

$$\begin{aligned}\Phi\left(\theta\right) = \quad & \alpha\theta I^4\left\{-\theta^2\left[n(1+I)(1+\alpha)+2\right]+\theta\alpha\left[n(1+I)(2+\alpha)+4\right]-\alpha^2\left[n(1+I)+2\right]\right\}\\ + \quad & \varphi\alpha\theta I\left\{-\theta^2\left[\Psi(1+\alpha)-2\right]+\theta\alpha\left[\Psi(2+\alpha)-4\right]-\alpha^2\left[\Psi-2\right]\right\}\\ + \quad & \beta I^4\left(\alpha-\theta\right)^2\left\{-2\alpha\left[n\left(1+I\right)-1\right]+\theta\left[2n(1+I)(1+\alpha)-3\alpha-2\right]\right\}\end{aligned}$$

with $\Psi = n(1+I)(2+3I)$.

Expression $\Phi\left(\theta\right)$ can be rewritten by:

$$\begin{aligned}\Phi\left(\theta\right) &= \alpha\theta I^4 \quad f(\theta)\\ &+ \varphi\alpha\theta I \quad g(\theta)\\ &+ \beta I^4\left(\alpha-\theta\right)^2 \quad h(\theta)\end{aligned} \tag{16}$$

Functions $f(\theta)$ and $g(\theta)$ are quadratic in θ and can be represented by a parabola that opens downwards. Both functions have two positive roots:
$\theta_1^f = \alpha\frac{n(1+I)+2}{n(1+I)(1+\alpha)+2}$ and $\theta_2^f = \alpha$ are the roots for $f(\theta)$ and
$\theta_1^g = \alpha\frac{n(1+I)(2+3I)-2}{n(1+I)(2+3I)(1+\alpha)-2}$ and $\theta_2^g = \alpha$ for $g(\theta)$.

As for function $h(\theta)$, it is linear in θ, taking negative values for $\theta < \theta_1^h = \alpha\frac{2[n(1+I)-1]}{2(1+\alpha)[n(1+I)-1]-\alpha}$ and positive values otherwise.[22]

[22]Note that $0 < \underline{\theta} < \theta_j^i \ \forall i = f, g, h$ and $\forall j = 1, 2$; $\underline{\theta}$ being the minimum value for θ defined in footnote 5.

By combining functions $f(\theta)$, $g(\theta)$ and $h(\theta)$, we can deduce that $\Phi(\theta)$ and thus $\left(\frac{\partial I^*}{\partial n}\right)$ are negative, for either extremely low values of θ or for $\theta > \alpha$. For intermediate levels of θ, $\Phi(\theta)$ and thus $\left(\frac{\partial I^*}{\partial n}\right)$ are positive.

Yet, when β is very large, the positive part of $h(\theta)$ compensates the negative part of $f(\theta)$ and $g(\theta) - \Phi(\theta)$ and thus $\left(\frac{\partial I^*}{\partial n}\right)$ becoming positive – for higher values of θ as $(\alpha - \theta)^2$, calibrating the weight of $h(\theta)$ in the third line of expression (16), increases with respect to θ.

Figures 4 and 5 represent (in blue) $\Phi(\theta)$ of expression $\left(\frac{\partial I^*}{\partial n}\right)$ in the cases where $\beta = 1$ and $\beta = 500$ respectively; the line in red representing $\Phi(\theta) = 0$. The numerical values that have been chosen for the different parameters are as follows: $\alpha = 2$, $n = 1$; $I = 1$ and $\varphi = 1$.

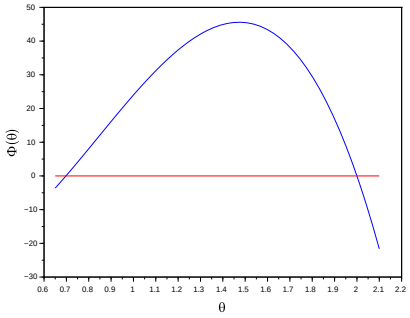

Figure 4: $\Phi(\theta)$ for $\beta = 1$

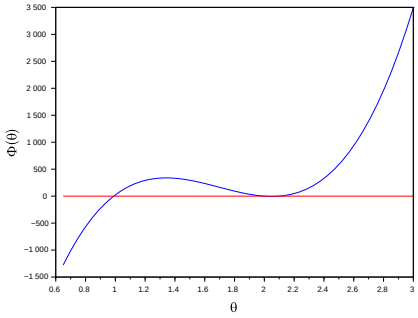

Figure 5: $\Phi(\theta)$ for $\beta = 500$

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Pôle Européen de Gestion et d'Economie
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67085 Strasbourg Cedex

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