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Fiscal Policies and Monetary Leadership in a Monetary Union with a Deficit-Concerned Central Bank

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Abstract

We consider fiscal and monetary policy interactions in a monetary union under monetary leadership, when the common central bank is concerned with the average fiscal stance of the union. We use a static two-country monetary union model to investigate the policy-mix problem under different regimes of non-cooperation, cooperation, and enforced cooperation among fiscal authorities. We find that fiscal policy is unambiguously countercyclical, a feature that is more pronounced under fiscal policy cooperation. Monetary policy can be either countercyclical or procyclical. A central bank concerned about the aggregate fiscal stance is effective in stabilizing output and central budget, but at the expense of inflation stabilization.

Keywords: strategic interactions, EMU, monetary leadership, fiscal cooperation, central bank's objectives

JEL Classification: E52, E58, E61, E62, E63.

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1 Introduction

This paper considers strategic interactions between fiscal and monetary policy in a monetary union. Countries participating in a monetary union, like the Economic and Monetary Union (EMU) in Europe, give up their currency and delegate monetary policy to a common central bank. The independent common central bank sets union-wide policy targets and uses the common nominal interest rate to accomplish them and stabilize the aggregate economy in response to potential shocks. The conventional wisdom that permeates the design of monetary unions, at least until the emergence of the ongoing crisis in the euro zone, has been that monetary union does not necessarily require centralized fiscal policy and participant countries use their fiscal policies to stabilize their domestic economy.

The above general framework has been used as a platform to consider analytically a number of policy design issues. Some researchers focus on the role of the shocks; common aggregate shocks versus idiosyncratic shocks, or asymmetric shocks, but with aggregate effects. Others examine the policymaker's targets relatively to their long-run equilibrium values, thus dealing with time-inconsistency issues or consider the strategic patterns of the common central bank and the decentralized fiscal authorities (e.g., leadership versus simultaneous moves). In this paper we cope with the policy-mix problem in a monetary union, focusing on whether the common monetary policy and the fiscal policy are in conflict relative to the business cycle. This approach follows (Andersen, 2008) who suggests that a conflict of this type emerges if, for example, one policy is expansionary and the other is restrictive.

We use a model that assumes identical but highly interdependent economies through traditional structural (trade) links and monetary policy implementation. We consider country-specific shocks that have aggregate effects focusing on the case of monetary leadership. More importantly, we incorporate the monetary union's aggregate fiscal stance in the central bank's loss function. The ongoing crisis in Europe reveals that in the absence of a centralized fiscal policy the common central bank cannot ignore fiscal developments in the countries that participate in the monetary union. The central bank's concern about the monetary union's aggregate fiscal stance gives rise to some interesting results, especially under monetary leadership.

The Treaty of Maastricht includes an explicit 'no-bail-out' clause but the unsustainable levels of public debt in EMU member-countries have undermined the financial markets' confidence to existing policy framework. Early enough many researchers voiced their concern that the Euro area needs a preventive procedure to avoid such an emergency (e.g., Baldwin and Wyplosz, 2004). Policymaking in the euro zone has been conducted under the principle that the fiscal stance of the EMU member nations should not be a primary concern of the common central bank. In this model, we consider the policy implications of a common central bank that put weight on aggregate fiscal stance under monetary leadership. This central bank takes into account the fiscal authorities' countercyclical reactions to shocks. Under this set of assumptions the common central bank emerges as less hard-nosed. We

use this framework to examine policy interactions in the cases of decentralized fiscal authorities, fiscal policy cooperation, and enforced policy cooperation.
The next section provides a selective review of the literature on policy interactions in monetary unions and Section 3 presents the model. Sections 4 and 5 analyze decentralized fiscal policy and fiscal policy cooperation respectively. Section 6 presents monetary policy, and thus provides final equilibrium solutions under both regimes. Section 7 deals with optimal policy, whereas sections 8 and 9 examine the enforced cooperation case; section 8 presents the monetary union's trustee problem, whereas section 9 focuses on monetary policy. Finally, section 10 concludes.

2 Review of the Literature

Given that an extensive literature on fiscal-monetary policy interactions in monetary unions exists we provide only an eclectic survey of the relevant research in this section. Policy interactions can be analyzed from many different perspectives, and this paper considers short-run stabilization issues of country-specific shocks in a monetary union, thus abstracting from important long-run fiscal policy issues, such as debt sustainability. The main focus of this paper is on the policy-mix problem in a monetary union and the resulting interaction between centralized monetary policy and decentralized fiscal policies.
A monetary union implies absence of monetary policy autonomy and thus, fiscal policy's role can be upgraded in the stabilization of country-specific shocks. In addition a possible failure of market mechanisms in a monetary union further enhances the potential role of fiscal policy. For example, Beetsma and Debrun (2004), highlight the absence of adjustment mechanisms or cross-country risk-sharing schemes. According to the traditional optimum currency area criterion, posed by Mundell (1961), there is no need to develop policies for country-specific shocks when significant factor mobility exists. The EMU, however, cannot be regarded as an optimum currency area, especially with regard to labor mobility as Baldwin and Wyplosz (2004) suggest.
Beetsma and Debrun (2004), distinguish the policy-mix problem in a monetary union between a 'horizontal' coordination problem and a 'vertical' coordination problem. The former corresponds to fiscal policy coordination and it is a problem across governments in a monetary union, whereas the latter refers to the coordination between monetary and fiscal policies, arising from the interaction between the common central bank and the fiscal authorities. In general, the policy-mix problem arises when whichever of the above coordination problems results in a conflict between the two policies relative to the business cycle situation (Andersen, 2008). In other words, the resulting equilibrium corresponds to one policy arm (fiscal/monetary) being expansionary, whereas the other (monetary/fiscal) being restrictive.
Early literature of short-run stabilization focused on the time-inconsistency problem emphasizing of the implications of fiscal policy for central bank's conservativeness

(e.g., Dixit, 2001; Dixit and Lambertini, 2001; 2003). This research uses the typical Barro-Gordon (1983) model, extended to incorporate fiscal policy in the form of a production subsidy, and examines policy interactions under conflicting goals between monetary and fiscal authorities. The common central bank incorporates two types of conservativeness, namely weight conservativeness (Rogoff, 1985) and target conservativeness (Svensson, 1997). The first one corresponds to more weight on inflation stabilization and less on output stabilization than society, whereas the second corresponds to lower output and inflation targets than the socially optimal ones. Both types of conservativeness can fight the inflation-bias problem in a Barro-Gordon framework (Walsh, 2003).

The main focus of this line of research has been on policy interactions under commitment and discretion, and under different assumptions about the sequencing of the game. Some standardized results include that agreement between the common central bank and the governments on the optimal levels of output and inflation, allows achieving the desired goals regardless of the sequencing of the game, the relative importance of goals, or any cooperation among them. Therefore, it is more important to reach an agreement over the desired goals than to appoint a conservative central banker (see Dixit and Lambertini, 2001). Moreover under policy interactions, a conservative central banker may make things worse. For example, Dixit and Lambertini (2003) show how fiscal discretion can destroy monetary commitment.

Even when the analysis is confined to models that conveniently assume time-consistent policies a number of modelling choices have to be made when considering policy interactions in a monetary union. The assumption of identical countries is typical and as the consideration of heterogeneity in the context of the policy-mix problem makes can make the solution intractable. In addition countries become interconnected or not via trade or financial links, the objectives across policy authorities may differ, and, alternative ways of sequencing the game may exist.

Lambertini and Rovelli (2004) use a New Keynesian framework (Clarida, Gali, Gertler (1999); Gali (2008)) that incorporates fiscal policy where both the nominal interest rate and government spending are perfect substitutes in the stabilization of shocks. In this static two-country monetary union model the two countries are assumed to be identical and no interconnections between them exist. They can be viewed as identical islands under a common monetary policy, as in Blinder and Mankiw (1984). The common central bank is concerned with aggregate inflation and the volatility of the interest rate, whereas the decentralized fiscal authorities are concerned with the output gap and the deviations of the balanced budget. The two authorities act simultaneously giving rise to Nash equilibrium outcomes but nevertheless a 'vertical' policy-mix problem arises.

Another spate of papers adopt the assumption that the national fiscal authorities are not directly concerned with inflation, but, apart from the output gap, they are also concerned with their fiscal stance (Gatti and Wijnbergen, 2002; Beetsma and Bovenberg, 2005; Uhlig, 2003). Different approaches exist regarding the sequencing of

policymakers' moves reflecting the different views about the institutional framework that best describes the monetary union. For example, Uhlig (2003), Beetsma and Debrun (2004), and Buti and Van den Noord (2004) argue for fiscal leadership. Other authors, however, argue for simultaneous moves or monetary leadership; Kirsanova, Stehn, Vines (2005), and Hughes Hallet (2005) respectively. Their main argument is that decentralized fiscal authorities are too many to act as leaders in EMU. Furthermore, Kirsanova, Stehn, Vines (2005) argue that the fiscal leadership framework might be appropriate only if fiscal authorities can cooperate with each other.

A key question emerges as to whether fiscal coordination leads to improved policy outcomes, or it enhances the 'vertical' coordination problem. Andersen (2008) examines the policy-mix problem arising under fiscal leadership, following Buti, Roeger, In't (2001). He considers identical countries with important interconnections, time-consistent policies, and national fiscal authorities that are concerned about deviations of output and government spending, whereas the common central bank cares about aggregate output and inflation deviations. The fact that monetary policy is known to the national fiscal authorities favors the argument for fiscal leadership. Although discretionary policies are analyzed, monetary policy is effectively committed, and this is clear to the fiscal authorities.

Andersen (2008) provides a positive analysis examining the policy-mix problem in the context of a monetary union. The normative analysis of the paper considers the optimal assignment of tasks between authorities. A key finding is that in the face of aggregate shocks, fiscal authorities underestimate the monetary reaction, resulting in excessively countercyclical fiscal policies, whereas in the case of idiosyncratic shocks, the monetary response is overestimated, and fiscal policy is insufficiently countercyclical. Further decentralization worsens the problem in the case of aggregate shocks, whereas it diminishes the problem under idiosyncratic shocks. Last but not least, flexible inflation targeting can overcome some of the problems of aggregate shocks.

3 A Baseline Model

We consider a monetary union which consists of i identical countries ($i = 1, 2$) which are interconnected via traditional trade links and monetary policy. The monetary union, however, is a closed economy, that is no interconnections exist with countries outside the union. We consider the case where one country, say country 1, faces a demand or supply side shock with aggregate effects and the union central bank must react to stabilize the monetary union's economy. We use a static two-country monetary union model, which is a modification of Andersen's (2008) model. The non-policy block for each country consists of a Phillips curve (PC) and an aggregate demand (AD) equation. This model is consistent with a model that emerges from a micro-founded model which incorporates monopolistic competition in product and

labor markets, along with sticky wages. The PC and AD equations for country 1 are,

$$\pi_1 = \omega_y y_1 + \omega_g g_1 - \varepsilon_1 \tag{1}$$

$$y_1 = -\delta_r i - \delta_\tau (\pi_1 - \pi) + \delta_y y + \delta_g g_1 + u_1. \tag{2}$$

All variables are in logs, apart from the nominal interest rate, and are considered as deviations from long-run equilibrium. The fiscal instrument, g, can be treated as a deviation from the balanced budget. In addition to its effect on output demand, the fiscal instrument has a direct effect on inflation, ω_g, which can be either positive or negative. Fiscal expansions financed by value-added and excise taxes generate inflationary pressures, but it is also possible that tax increases lead to wage moderation, or they can be interpreted as production subsidies (see Andersen, 2008). In general, we assume that the total effect of the fiscal instrument on both output demand and inflation is positive, so that $\frac{\partial \pi_i}{\partial g_i} = \omega_g + \omega_y \cdot \frac{\partial y_i}{\partial g_i} = \omega_g + \omega_y \delta_g > 0$, and $\frac{\partial y_i}{\partial g_i} = \delta_g - \delta_\tau \cdot \frac{\partial \pi_i}{\partial g_i} = \delta_g - \delta_\tau \omega_g > 0$.
The second term in the AD equation is the terms-of-trade effect, capturing the structural aspect of interdependence; higher prices of domestic products shift domestic demand to foreign products. All the parameters in the AD are positive. Finally, we consider two types of i.i.d shocks. In particular, country 1 has to cope with either a pure demand shock that increases aggregate demand, or a pure supply shock which reduces inflation when it is positive, like a technology improvement. Finally for every variable x, it holds that $x = \frac{1}{2} \sum_{i=1}^{2} x_i = \frac{1}{2} (x_1 + x_2)$.
Turning now to country 2, the PC and AD are:

$$\pi_2 = \omega_y y_2 + \omega_g g_2 \tag{3}$$

$$y_2 = -\delta_r i - \delta_\tau (\pi_2 - \pi) + \delta_y y + \delta_g g_2. \tag{4}$$

After aggregation, we can represent the union-wide non-policy block as

$$\pi = \omega_y y + \omega_g g - \frac{1}{2}\varepsilon_1 \tag{5}$$

$$y = \frac{1}{1 - \delta_y} \cdot \left(-\delta_r i + \delta_g g + \frac{1}{2} u_1 \right). \tag{6}$$

Our objective is to investigate the policy-mix problem in the monetary union that arises from the interaction between the common central bank and the decentralized fiscal authorities under monetary leadership. The case of fiscal leadership is thoroughly analyzed by Andersen (2008) who considers a credible monetary policy with clearly defined objectives and preferences that are efficiently communicated to the public. Thus, the (national) fiscal authorities can infer the central bank's reaction function. Andersen (2008) assumes that the common central bank is the follower, and the decentralized fiscal authorities are the leaders. Of course the monetary leadership

case, which could possibly best describe the existing institutional arrangement of EMU, would be another interesting scenario to consider. In that case the common central bank plays first, taking into account fiscal authorities' reaction, even though its leadership is considered weak (Hughes Hallett, 2005). Monetary leadership involves a Stackelberg equilibrium, while the decentralized fiscal authorities make decisions simultaneously, involving a Nash equilibrium among them.
The loss functions of the common central bank (denoted by subscript M) and the decentralized fiscal authorities (denoted by subscript F_i) are:

$$L_M = \frac{1}{2} \cdot \left(a_y y^2 + \pi^2 + a_g g^2\right) \tag{7}$$

$$L_{F_i} = \frac{1}{2} \cdot \left(b_y y_i^2 + b_g g_i^2\right). \tag{8}$$

Both fiscal and monetary authorities seek to minimize deviations of their concerned variables from long-run equilibrium. Thus, we assume that time-inconsistency problems do not arise. In particular, we assume that the decentralized fiscal authorities are concerned with the output gap and the deviation from the balanced budget for their own country, whereas the common central bank is concerned with output gap, balanced budget, and inflation in the monetary union. Our main focus is on the fiscal stance and on its weight by authorities. As in Andersen (2008), we include each country's fiscal stance in their loss functions. In the context of the EMU this reflects the constraints implied by the Stability and Growth Pact (SGP), which requires that the fiscal stance must be on average neutral, $g_i = 0$, so that departures from a balanced budget should be only small and temporary (Lambertini and Rovelli, 2004).
The hypothesis that the common central bank is also concerned with average fiscal stance in the union, leads to the introduction of the aggregate fiscal stance in the monetary union as an argument in the common central bank's loss function. The rationale is the same as with that of the (SGP), i.e., that the accumulation of excessive debt in the union member countries may create pressures for the central bank to shift focus away from its price stability and output stabilization objectives. The concern for the aggregate fiscal stance coupled with the assumption of monetary leadership, introduces some new perspectives in both vertical and horizontal coordination problems. Under monetary leadership, the common central bank is constrained by a direct link between the two instruments, (i.e., aggregate fiscal stance and the nominal interest rate), as it knows that the fiscal authorities will react to the interest rate. This reaction is expected to be positive, as a rise in the nominal interest rate is expected to lower demand, and fiscal authorities raise government spending in order to boost demand. This is the source of the policy-mix problem; a restrictive monetary policy leads to an expansionary fiscal policy. Thus, under monetary leadership, the common central bank needs to take into account this channel, which might make the decision over the weight of the average fiscal stance

non-trivial.

In addition, a coordination problem among the decentralized fiscal authorities, apart from the standard policy-mix problem, might also arise. To examine this possibility we consider the fiscal authorities' cooperation over fiscal policy and treat the coalition's loss function as the average of the other two independent loss functions, that is:

$$L_F = \frac{1}{2} \cdot \sum_{i=1}^{2} L_{F_i}. \tag{9}$$

Each fiscal authority chooses its own instrument in order to minimize the aggregate loss function (9). Andersen (2008) shows that in the case of aggregate common shocks, the coordination problem arises because fiscal policy is more countercyclical under decentralized fiscal authorities as compared to fiscal cooperation, and fiscal policy emerges as unambiguously procyclical. Fiscal expansions that increase inflation lead to output contraction, and vice versa. At the country level, however, the usual aggregate demand effects of fiscal policy emerge, which also determine the relative outputs of the countries. This is the source of the coordination problem and the main conclusion is that this problem worsens with further decentralization, while the introduction of flexible inflation targeting, can moderated it. Flexible inflation targeting implies that the common central bank should be also concerned with union-wide output gap along with inflation, but with a weight less than that of the fiscal authorities.

Our model considers the coordination problems under monetary leadership, when the common central bank is also concerned with the average fiscal stance of the union. In addition to the above questions, we go one step further, and introduce a third player in the game who acts as the monetary union's political trustee. The typical framework of fiscal monetary policy interactions assumes that the principal responsible for policy design at the monetary union level is solely the union central bank. This is clearly insufficient given the current consensus on what the mandate of the central bank should be and given the experience of the EMU in Europe. In order to capture existing debates about enforced fiscal cooperation in the EMU (and in particular in the European Commission) we introduce another authority, the European Commission (EC), who sets guidelines for fiscal policy in each country, and thus acts as a principal to the ECB. In particular, we assume that EC enforces both decentralized fiscal authorities to choose their fiscal stance by minimizing the following loss function

$$L_{EC} = L_F + \frac{1}{2}\pi^2. \tag{10}$$

Lambertini and Rovelli (2004) consider a similar problem where the EC minimizes a loss function that incorporates the cooperative fiscal authorities' loss function and the loss function of the common central bank in a straightforward additive way. They assume that society's preferences coincide with those of the EC. In our model, the EC aims to enforce cooperation among the decentralized fiscal authorities and cares

about union-wide inflation with the same weight as the common central bank does. Finally, we can consider optimal policy by letting the society's preferences corresponding to a loss function that incorporates the common central bank's loss function with the one from the fiscal cooperation case, that is:

$$L_S = L_M + L_F. \tag{11}$$

Alternatively, this problem can be thought as one of fiscal and monetary policy cooperation.

4 Decentralized Fiscal Policies

The timing of the model has the shocks realized first and then policies responding to them. Under monetary leadership, decentralized fiscal authorities decide on the domestic fiscal stance after the common central bank has set the nominal interest rate. Each fiscal authority decides simultaneously its action with the other so that they do not consider each other's decision problem. Thus, in the game between the common central bank and the decentralized fiscal authorities, each fiscal authority is the follower. We solve the model using backward induction and taking the aggregate π and y as given. Each fiscal authority solves the following problem

$$\begin{aligned}
&\min_{g_i} \left\{ L_{F_i} = \tfrac{1}{2} \cdot \left(b_y y_i^2 + b_g g_i^2 \right) \right\}, \text{ subject to} \\
&\pi_i = \omega_y y_i + \omega_g g_i - \varepsilon_i \\
&y_i = -\delta_r i - \delta_\tau \left(\pi_i - \pi \right) + \delta_y y + \delta_g g_i + u_i,
\end{aligned}$$

where shocks are only for country 1. The first order condition for this problem is

$$\frac{\partial L_{F_i}}{\partial g_i} = 0 \Rightarrow g_i = -\phi_g^{nc} y_i \quad : FR_i^{nc} \tag{12}$$

where $\phi_g^{nc} = \dfrac{b_y}{b_g} \cdot \dfrac{\delta_g - \delta_\tau \omega_g}{1 + \delta_\tau \omega_y} > 0.$

Equation (12) represents the fiscal rule of each country in the case of decentralized fiscal authorities. It gives the reaction of fiscal authorities to any given output deviation from long-run equilibrium. The positive reaction parameter ϕ_g^{nc} in this fiscal rule implies that fiscal policy is unambiguously countercyclical. For example, if domestic output is less than its equilibrium level, the fiscal authority's reaction would be to expand the fiscal stance in order to boost demand. The reaction parameter depends positively on the impact of domestic fiscal policy on domestic output, after taking into account its impact upon inflation and the corresponding result through the terms-of-trade effect. The larger this impact, the more countercyclical the fiscal policy is. Furthermore, it depends on the relative weight that decentralized fiscal authorities place upon output versus its fiscal stance. If the weight on output is

larger than the one upon the fiscal stance fiscal policy becomes more countercyclical. After aggregation, we get

$$g = -\phi_g^{nc} y : FR^{nc} \tag{13}$$

This is the aggregate fiscal rule for the non-cooperative case that becomes a constraint to the common central bank. The central bank must incorporate this decision rule in its decision about setting the interest rate. It knows that the nominal interest rate affects aggregate output and output per country, thus the decentralized fiscal authorities would respond to it. Knowing how changes in the countries' fiscal stance affect aggregate output and inflation, it also knows how the given decision affects the final outcome at the monetary union level. These aggregate equilibrium solutions for the fiscal stance, output and inflation are functions of the nominal interest rate and shocks.

Substituting for aggregate output (eq. 6) into the union-wide fiscal rule (eq. 13) and solving for the aggregate fiscal stance under decentralized fiscal authorities we obtain:

$$g^{nc} = \frac{\phi_g^{nc}}{1 - \delta_y + \delta_g \phi_g^{nc}} \delta_r i - \frac{1}{2} \cdot \frac{\phi_g^{nc}}{1 - \delta_y + \delta_g \phi_g^{nc}} u_1 \tag{14}$$

When $\delta_y < 1 + \delta_g \phi_g^{nc}$, an increase in the interest rate results in expansion of the aggregate fiscal stance in the monetary union. Furthermore, if $\delta_y < 1$, this impact will be higher the more countercyclical fiscal policies are. Apart from the change in the interest rate, the aggregate fiscal stance reacts directly to a demand shock that hits country 1. Under the same circumstances, a positive demand shock makes the aggregate fiscal stance to decrease.

To obtain the solutions for output and inflation, we first substitute the previous solution for the aggregate fiscal stance (eq. 14) in the union-wide fiscal rule (eq. 13) to obtain equilibrium output, and then we incorporate both solutions to the union-wide PC (eq. 5). The resulting expressions are:

$$y^{nc} = -\frac{1}{1 - \delta_y + \delta_g \phi_g^{nc}} \delta_r i + \frac{1}{2} \cdot \frac{1}{1 - \delta_y + \delta_g \phi_g^{nc}} u_1 \tag{15}$$

$$\pi^{nc} = -\frac{\omega_y - \omega_g \phi_g^{nc}}{1 - \delta_y + \delta_g \phi_g^{nc}} \delta_r i + \frac{1}{2} \cdot \frac{\omega_y - \omega_g \phi_g^{nc}}{1 - \delta_y + \delta_g \phi_g^{nc}} u_1 - \frac{1}{2} \varepsilon_1. \tag{16}$$

The equilibrium output falls in response to nominal interest rate increases. In the absence of a demand shock, monetary policy prevails over fiscal policy under decentralized fiscal authorities. This impact is naturally lower the higher the fiscal reaction parameter is. Equilibrium inflation decreases when nominal interest rate increases if $\omega_y > \omega_g \phi_g^{nc}$, suggesting that output's direct effect upon inflation is higher than the effect of aggregate fiscal stance upon inflation through fiscal reaction. This adds more credit to monetary policy prevalence and occurs under $\omega_g > 0$. We discuss the importance of the ω_g in what follows. Moreover, if $\omega_g + \delta_g \omega_y > \omega_g \delta_y$, then the

previous impact decreases with the increase of the fiscal reaction parameter, in other words with more countercyclical fiscal policy.
Turning to the country-specific equilibrium output and inflation, we start from country 1 and substitute for aggregate output (6) into the country's output demand equation (2), to obtain relative output as:

$$y_1 - y = -\delta_\tau (\pi_1 - \pi) + \delta_g (g_1 - g) + \frac{1}{2} u_1.$$

Similarly, relative inflation emerges as:

$$\pi_1 - \pi = \omega_y (y_1 - y) + \omega_g (g_1 - g) - \frac{1}{2} \varepsilon_1.$$

Using relative inflation into relative output we have:

$$y_1 - y = \frac{\delta_g - \delta_\tau \omega_g}{1 + \delta_\tau \omega_y} (g_1 - g) + \frac{1}{2} \cdot \frac{\delta_\tau \varepsilon_1 + u_1}{1 + \delta_\tau \omega_y}.$$

In the absence of shocks, output in country 1 can only differ from the union-wide output if fiscal policy is different. Using country's 1 fiscal rule, we obtain the equilibrium relative output under decentralized fiscal authorities,

$$y_1^{nc} = y^{nc} + \frac{1}{2} \cdot \frac{b_y (\delta_\tau \varepsilon_1 + u_1)}{b_y (1 + \delta_\tau \omega_y) + b_g \left(\phi_g^{nc}\right)^2}. \tag{17}$$

Knowing the union-wide output under non-cooperation (eq. 11), we can compute output for country 1 as a function of the two shocks and the interest rate. Output in country 1 is negatively related to the interest rate, by the same parameter as aggregate output.
Using the same procedure for country 2 we obtain

$$y_2^{nc} = y^{nc} - \frac{1}{2} \cdot \frac{b_y (\delta_\tau \varepsilon_1 + u_1)}{b_y (1 + \delta_\tau \omega_y) + b_g \left(\phi_g^{nc}\right)^2}. \tag{18}$$

Subtracting the output of country 2 from the output of country 1 under non-cooperation (equations 18 and 17 respectively), we obtain:

$$y_1^{nc} - y_2^{nc} = \frac{b_y (\delta_\tau \varepsilon_1 + u_1)}{b_y (1 + \delta_\tau \omega_y) + b_g \left(\phi_g^{nc}\right)^2}. \tag{19}$$

Equation (19) expresses the output differential in the two countries in terms of parameters and shocks. If the shocks are positive, the output gap in country 1 is unambiguously higher than the output gap in country 2, and vice versa. In addition, for higher fiscal reaction parameters, which imply more countercyclical fiscal policies, this difference decreases. Output differences across countries do not depend on monetary policy.

5 Cooperation among Fiscal Authorities

Under centralized fiscal policy, fiscal authorities cooperate with each other by choosing their fiscal stance in order to minimize the same aggregate loss function (eq. 9). The problem now becomes

$$\min_{g_1,g_2}\left\{L_F=\frac{1}{2}\sum_{i=1}^{2}L_{F_i}=\frac{1}{2}\left(L_{F_1}+L_{F_2}\right)=\frac{1}{2}\left[\frac{1}{2}b_y\left(y_1^2+y_2^2\right)+\frac{1}{2}b_g\left(g_1^2+g_2^2\right)\right]\right\},$$

subject to each country's PC and AD equations (1-4), and to the aggregate relations. The first order condition with respect to country's 1 fiscal stance emerges as:

$$\frac{\partial L_F}{\partial g_1}=0\Rightarrow g_1=-\phi_g^{nc}\left(y_1+\frac{1}{2}\delta_y y_2\right)-\frac{1}{2}\cdot\frac{b_y}{b_g}\delta_\tau\left(\omega_g+\omega_y\delta_g\right)y_2:FR_1^c.$$

This fiscal rule shows that fiscal policy under cooperation is unambiguously countercyclical, as it is in the non-cooperative case. The first order condition with respect to country's 2 fiscal stance gives its symmetrical fiscal rule under cooperation

$$g_2=-\phi_g^{nc}\left(y_2+\frac{1}{2}\delta_y y_1\right)-\frac{1}{2}\cdot\frac{b_y}{b_g}\delta_\tau\left(\omega_g+\omega_y\delta_g\right)y_1:FR_2^{nc}.$$

The difference between the cooperative case and the non-cooperative one is that under cooperation, each fiscal authority reacts with the same sign not only to its own output, but also to the other fiscal authority's output. To illustrate this point, we rewrite country's 1 fiscal rule, as

$$g_1=-\phi_g^{nc}y_1-\frac{1}{2}\cdot\frac{b_y}{b_g}\left[\delta_y\left(\delta_g-\delta_\tau\omega_g\right)+\delta_\tau\left(\omega_g+\omega_y\delta_g\right)\right]y_2. \tag{20}$$

The parameter in brackets in front of country's 2 output captures the impact of country's 1 fiscal stance on country's 2 output, and it simultaneously expresses the interconnections between the two countries. The first term corresponds to the aggregate demand channel, while the second term to the terms-of-trade channel. After aggregation, we obtain

$$g^c=-\phi_g^c y^c:FR^c, \tag{21}$$

where $\phi_g^c=\left(1+\frac{1}{2}\delta_y\right)\phi_g^{nc}+\frac{1}{2}\cdot\frac{b_y}{b_g}\delta_\tau\left(\omega_g+\omega_y\delta_g\right)$. This is the union-wide fiscal rule for the cooperative case and shows that fiscal policy is unambiguously countercyclical as in the non-cooperative case. Moreover, its countercyclical nature is more pronounced since:

$$\begin{aligned}\phi_g^c-\phi_g^{nc} &= \left(1+\tfrac{1}{2}\delta_y\right)\phi_g^{nc}+\tfrac{1}{2}\cdot\tfrac{b_y}{b_g}\delta_\tau\left(\omega_g+\omega_y\delta_g\right)-\phi_g^{nc}= \\ &= \tfrac{1}{2}\left[\delta_y\phi_g^{nc}+\tfrac{b_y}{b_g}\delta_\tau\left(\omega_g+\omega_y\delta_g\right)\right]>0.\end{aligned} \tag{22}$$

Under fiscal cooperation, the fiscal authorities understand the interconnections between the two countries. Thus, a coordination problem in fiscal policies arises under decentralized fiscal authorities. Moreover, and as a consequence of monetary leadership, this fiscal coordination problem does not depend on monetary policy.
We follow a similar procedure as for the non-cooperative case above to obtain solutions for the fiscal stance, output and inflation, at the union-wide and country-specific level. Thus, all the solutions are symmetric and depend on the cooperative fiscal reaction parameter (ϕ_g^c). That is,

$$g^c = \frac{\phi_g^c}{1-\delta_y+\delta_g\phi_g^c}\delta_r i - \frac{1}{2}\cdot\frac{\phi_g^c}{1-\delta_y+\delta_g\phi_g^c}u_1 \tag{23}$$

$$y^c = -\frac{1}{1-\delta_y+\delta_g\phi_g^c}\delta_r i + \frac{1}{2}\cdot\frac{1}{1-\delta_y+\delta_g\phi_g^c}u_1 \tag{24}$$

$$\pi^c = -\frac{\omega_y-\omega_g\phi_g^c}{1-\delta_y+\delta_g\phi_g^c}\delta_r i + \frac{1}{2}\cdot\frac{\omega_y-\omega_g\phi_g^c}{1-\delta_y+\delta_g\phi_g^c}u_1 - \frac{1}{2}\varepsilon_1 \tag{25}$$

It is obvious that with $\phi_g^c > \phi_g^{nc}$, the negative impact of monetary policy on output is lower under cooperation, and so is the impact of the demand shock. Thus, the results of the non-cooperative case emerge under the cooperative case as well, but they are milder. The same reasoning holds for inflation.
Finally, we compute equilibrium solutions for each country, reporting only those for output gap (We do not report detailed results for other variables due to space limitations but they are available upon request):

$$y_1^c = y^c + \frac{1}{2}\cdot\frac{\delta_\tau\varepsilon_1+u_1}{b_y\left(1+\delta_\tau\omega_y\right)+\phi_g^{nc}\left[b_g\left(1-\frac{1}{2}\delta_y\right)\phi_g^{nc}-\frac{1}{2}b_y\delta_\tau\left(\omega_g+\omega_y\delta_g\right)\right]} \tag{26}$$

$$y_2^c = y^c - \frac{1}{2}\cdot\frac{\delta_\tau\varepsilon_1+u_1}{b_y\left(1+\delta_\tau\omega_y\right)+\phi_g^{nc}\left[b_g\left(1-\frac{1}{2}\delta_y\right)\phi_g^{nc}-\frac{1}{2}b_y\delta_\tau\left(\omega_g+\omega_y\delta_g\right)\right]} \tag{27}$$

The difference between output gaps in each country at equilibrium with respect to the two shocks hitting country 1, is

$$y_1^c - y_2^c = \frac{1}{2}\cdot\frac{\delta_\tau\varepsilon_1+u_1}{b_y\left(1+\delta_\tau\omega_y\right)+\phi_g^{nc}\left[b_g\left(1-\frac{1}{2}\delta_y\right)\phi_g^{nc}-\frac{1}{2}b_y\delta_\tau\left(\omega_g+\omega_y\delta_g\right)\right]} \tag{28}$$

Equation (28) differs from equation (19) in that its sign cannot be determined, as it depends on the parameters. Thus, a positive shock either on the demand or on the supply side of country's 1 economy may lead to an output gap in country 1 which is lower than that in country 2. Under fiscal cooperation, fiscal authorities incorporate the aggregate demand effect and the terms-of-trade effect caused by the fiscal reaction to the shock. If these effects are stronger, country 1 may end up with a negative output gap after a positive shock.

6 Monetary Policy Leadership

Assigning leadership to the common central bank implies that it takes into account the fiscal authorities' decision rules. Thus, we can exploit the equilibrium solutions for union-wide fiscal stance, output and inflation under both non-cooperative and cooperative fiscal policy with respect to monetary policy (eq. 14, 15, 16, and 23, 24, 25, respectively). The common central bank's problem can be stated as

$$\begin{aligned}
&\min_i \left\{ L_M = \tfrac{1}{2} \cdot \left(a_y y^2 + \pi^2 + a_g g^2 \right) \right\}, \text{ subject to} \\
&g = \frac{\phi_g}{1 - \delta_y + \delta_g \phi_g} \delta_r i - \tfrac{1}{2} \cdot \frac{\phi_g}{1 - \delta_y + \delta_g \phi_g} u_1 \\
&y = -\frac{1}{1 - \delta_y + \delta_g \phi_g} \delta_r i + \tfrac{1}{2} \cdot \frac{1}{1 - \delta_y + \delta_g \phi_g} u_1 \\
&\pi = -\frac{\omega_y - \omega_g \phi_g}{1 - \delta_y + \delta_g \phi_g} \delta_r i + \tfrac{1}{2} \cdot \frac{\omega_y - \omega_g \phi_g}{1 - \delta_y + \delta_g \phi_g} u_1 - \tfrac{1}{2} \varepsilon_1
\end{aligned}$$

where ϕ_g corresponds to the fiscal reaction parameter and is specified as ϕ_g^{nc} for the decentralized fiscal authorities and ϕ_g^c for fiscal cooperation. The first order condition for this problem is

$$\frac{\partial L_M}{\partial i} = 0 \Rightarrow y = -\phi_\pi \pi \quad : MR, \tag{29}$$

where $\phi_\pi = \dfrac{\omega_y - \omega_g \phi_g}{a_y + a_g \phi_g^2}$.

Equation (29) corresponds to the monetary rule of the common central bank and shows the way the common central bank reacts to changes in inflation. As the denominator is always positive, we focus on the sign of the nominator which shows the impact of union-wide output to inflation after taking into account the reaction of the union-wide fiscal stance to output and its impact on inflation.

The common central bank manipulates the uses the nominal interest rate in the typical way. For example, when inflation increases the common central bank raises the nominal interest rate. For this policy to be successful, however, the central bank must know how output affects inflation. A straightforward effect exists of course from output decreases/increases to inflation decreases/increases. The central bank, however, must also consider the fiscal reaction to a decrease in output. As fiscal policy is countercyclical under both regimes, the decrease in output leads to a fiscal expansion by the fiscal reaction parameter, which adds to inflation, if $\omega_g > 0$. Thus, the final impact of output upon inflation is not known.

In particular, let $\omega_g > 0$. If $\omega_y > \omega_g \phi_g$, then the direct impact of output upon inflation prevails and monetary policy is countercyclical too; an increase in inflation makes the common central bank to increase the interest rate so as to reduce output, and finally, as its direct impact prevails to the one through fiscal reaction, reduces inflation. If, however, $\omega_y < \omega_g \phi_g$, then the fiscal reaction prevails, which renders monetary policy procyclical. An increase in inflation generated by a negative supply

shock in country 1 makes the common central bank to lower the interest rate so as to increase output. This happens because the central bank understands that the fiscal authorities will react to this output increase by shrinking the union-wide fiscal stance. This directly decreases output, and finally inflation decreases as well. Last but not least, if $\omega_g < 0$, then monetary policy is unambiguously countercyclical.
Computing the final equilibrium solutions for union-wide output and inflation requires solving the monetary rule (eq. 29) with respect to the interest rate, using equations (24) and (25), or (15) and (16). This exercise gives:

$$i = \frac{1}{2} \cdot \frac{1}{\delta_r} u_1 - \frac{1}{2} \cdot \frac{1}{\delta_r} \cdot \frac{\phi_\pi \left(1 - \delta_y + \delta_g \phi_g\right)}{1 + \phi_\pi \left(\omega_y - \omega_g \phi_g\right)} \varepsilon_1. \tag{30}$$

This is the interest rate rule for the common central bank. It shows the sign and magnitude of the monetary instrument's reaction to the shocks. Again, the parameter ϕ_g^{nc} corresponds to the decentralized fiscal authorities, while ϕ_g^c to fiscal cooperation. At this point instead of proceeding directly with an analysis of the previous interest rate rule, we first provide the corresponding solutions for the union–wide fiscal stance, output, and inflation.
Thus, by substituting for the interest rate solution into the three constraints of the common central bank, we end up with equilibrium solutions, as

$$g = -\frac{1}{2} \cdot \frac{\phi_\pi \phi_g}{1 + \phi_\pi \left(\omega_y - \omega_g \phi_g\right)} \varepsilon_1 \tag{31}$$

$$y = \frac{1}{2} \cdot \frac{\phi_\pi}{1 + \phi_\pi \left(\omega_y - \omega_g \phi_g\right)} \varepsilon_1 \tag{32}$$

$$\pi = -\frac{1}{2} \cdot \frac{1}{1 + \phi_\pi \left(\omega_y - \omega_g \phi_g\right)} \varepsilon_1. \tag{33}$$

These are the final solutions for the monetary leadership game of one common central bank against two fiscal authorities corresponding to two identical countries that form a monetary union, when the two countries are interconnected via monetary policy and a terms-of-trade effect, and when country 1 is hit by either demand or supply side shocks. Using ϕ_g^{nc} and ϕ_π^{nc} we obtain the solutions for the case of decentralized fiscal authorities, while using ϕ_g^c and ϕ_π^c we obtain the solutions for the cooperative case. These solutions are consistent with Andersen's (2008) results, with the obvious difference that the reaction terms are functions of different parameters, as our model considers monetary leadership.
What are the implications of these findings? In the first stage, we examine a positive pure demand shock that hits country 1, u_1 and has aggregate effects equal to $\frac{1}{2}u_1$. These aggregate effects increase output in the monetary union, which in turn leads to an increase in inflation. Given the common central bank's loss function, the central bank reacts to this development by increasing the nominal interest rate by $\frac{1}{\delta_r}$. This reduces aggregate output and thus inflation. The above equilibrium solutions for the

aggregate fiscal stance, output and inflation do not depend on the demand shock. Under a (positive or negative) pure demand shock monetary policy carries out the task of fully stabilizing the aggregate effects of the shock. Thus, the fiscal authorities do not respond to demand shocks, coordination problems do not arise, and aggregate output and inflation equal their long-run equilibrium levels.

In the second stage, we examine a negative pure supply shock that increases inflation in country 1, $\varepsilon_1 < 0$. The aggregate effects of this shock are $\frac{1}{2}\varepsilon_1$, which increase inflation in the monetary union and the common central bank reacts according to its monetary rule. Under either $\omega_g > 0$ and $\omega_y > \omega_g\phi_g$ or $\omega_g < 0$, the common central bank raises the nominal interest rate to reduce aggregate output leading also to a reduction in each country's output. The fiscal authorities then reacting in unambiguously countercyclical way expand their fiscal stance under both the non-cooperative and cooperative regimes. Thus, in equilibrium the aggregate the fiscal stance increases, aggregate output decreases and inflation increases. Given the strong countercyclical nature of fiscal policies under fiscal cooperation, however, this result is more profound under the non-cooperative regime.

A substantial remark can be made at this point about inflation. All equilibrium solutions (31-33) have the same denominator, which is unambiguously positive. Equation (33) reveals that the parameter of the shock is always negative, regardless of parameter values and the nature of fiscal cooperation. Thus, in equilibrium a positive/negative supply shock reduces/increases inflation. When $\omega_g > 0$ but $\omega_y < \omega_g\phi_g$, monetary policy is procyclical. Negative supply shocks induce the common central bank to reduce the nominal interest rate, which also leads to a decreasing aggregate fiscal stance. In equilibrium, aggregate output exceeds its log-run equilibrium value.

To summarize our results, we observe that a policy-mix problem exists, in the sense that when monetary policy is expansionary, fiscal policy is restrictive, and vice versa. Secondly, aggregate output in equilibrium is determined by monetary policy as it exceeds its long-run equilibrium level when monetary policy is expansionary and falls short of it when monetary policy is restrictive. Thirdly, equilibrium inflation is always negatively related to the supply shock. Negative/positive supply shocks lead to inflation exceeding/falling short of its long-run equilibrium value. In complete contrast with aggregate output, inflation is determined by fiscal policy. The preceding analysis, of course, holds for $\delta_y < 1 + \delta_g\phi_g$.

The monetary rule of the common central bank (eq. 29) reveals that both weights on union-wide output and fiscal stance have no impact on the sign of the reaction parameter, ϕ_π and do not determine countercyclicality/procyclicality. Both play an important role, however, in determining how strongly monetary policy reacts to inflation. Under strict inflation targeting, where the common central bank is only concerned with minimizing inflation deviations from long-run equilibrium ($a_y = a_g = 0$) monetary policy is successful in taming inflation. By contrast, when the common central bank is concerned with more variables, its reaction to inflation

weakens. For any given output weight, the central bank's concern with aggregate fiscal stance weakens its reaction to inflation. The stronger this concern, the weaker the monetary reaction. In this case the central bank has three targets, but only one instrument.

Finally, we examine the implications of the common central bank's fiscal concern parameter for stabilization policy. Considering the variances of output and inflation (eq. 32 and 33) at equilibrium, it is straightforward that $\frac{\partial[Var(y)]}{\partial a_g} < 0$ and $\frac{\partial[Var(\pi)]}{\partial a_g} > 0$. That is, while the central bank's fiscal concern parameter facilitates output stabilization at the union level, at the same time it destabilizes union-wide inflation. This result pertains to supply shocks only, as under demand shocks the economy at the union level is fully stabilized. Moreover, by considering the variance of the aggregate fiscal stance, one can easily see that $\frac{\partial[Var(g)]}{\partial a_g} < 0$. Thus, the existence of the common central bank's concern on the aggregate fiscal stance works for output and central budgets stabilization for the monetary union as a whole, but at the expense of higher inflation.

7 Optimal Policy Assignment

To compute optimal policy we assume a benevolent dictator who chooses both policy instruments simultaneously to minimize society's loss function. The last includes the loss functions of the common central bank's and of the fiscal authorities' under cooperation (eq. 11). Thus, the benevolent policymaker minimizes:

$$\min_{g,i} \left\{ L_S = L_M + L_F = \frac{1}{2}\left[a_y y^2 + \frac{1}{2} b_y \left(y_1^2 + y_2^2 \right) + \pi^2 + a_g g^2 + \frac{1}{2} b_g \left(g_1^2 + g_2^2 \right) \right] \right\},$$

subject to each country's PC and AD equations (1-4), and to the aggregate relations. The first order conditions with respect to aggregate fiscal stance and the nominal interest rate, delivers a monetary and a fiscal policy rule as follows:

$$y = -\phi_\pi^S \pi \quad : MR^S \tag{34}$$

$$g = \phi_g^S y \quad : FR^S \tag{35}$$

where $\phi_\pi^S = \dfrac{\omega_y}{a_y + b_y \left(1 + \delta_\tau \omega_y\right)}$ and $\phi_g^S = \dfrac{\omega_g}{a_g \phi_\pi^S} + \dfrac{\delta_g b_y \left(1 - \delta_y + \delta_\tau \omega_y\right)}{a_g \left(1 - \delta_y\right)}$.

The monetary reaction parameter, ϕ_π^S, is definitely positive, so that optimal monetary policy is unambiguously countercyclical. The central bank's weight upon the aggregate fiscal stance does not affect the magnitude of its reaction parameter. By contrast, the weights that the common central bank and the decentralized fiscal authorities place upon output are negatively related to the reaction parameter. If society increases its concern on output the monetary reaction parameter declines.

The fiscal reaction parameter can be either positive or negative. For $\omega_g > 0$, if $\delta_y < 1$

optimal fiscal policy must be procyclical, while if $\delta_y > 1$ is undetermined. Under $\omega_g < 0$, the result is indeterminate in the first case, while optimal fiscal policy is countercyclical in the second case. The fiscal reaction parameter decreases with the increase of central bank's weight upon the union-wide fiscal stance. Under monetary leadership, the above results reveal a completely inappropriate policy mix, in the sense that monetary policy is less countercyclical and fiscal policy is too countercyclical, especially under fiscal cooperation.

To characterize the optimal union-wide output and inflation we start by using the optimal fiscal rule (eq. 35) for the aggregate fiscal stance in the aggregate PC (eq. 5), and then use the optimal monetary rule (eq. 34) to substitute for aggregate output. Using the optimal monetary rule for aggregate output's optimal solution and solving for union-wide inflation we obtain:

$$\pi^S = -\frac{1}{2} \cdot \frac{1}{1 + \phi_\pi^S \left(\omega_y + \omega_g \phi_g^S\right)} \varepsilon_1 \tag{36}$$

$$y^S = \frac{1}{2} \cdot \frac{\phi_\pi^S}{1 + \phi_\pi^S \left(\omega_y + \omega_g \phi_g^S\right)} \varepsilon_1. \tag{37}$$

When fiscal policy is procyclical ($\omega_g > 0$ and $\phi_g^S > 0$) aggregate output and aggregate inflation in equilibrium are positively and negatively related to supply shocks respectively.

8 Enforced Fiscal Cooperation: The Monetary Union's Trustee Problem

Under a scheme of enforced fiscal cooperation a new player emerges, namely the "trustee" of the monetary union, which in the context of the EMU can be approximated by the European Commission (EC). To solve the EC's optimization problem we observe that both decentralized fiscal authorities choose their respective fiscal stance to minimize equation (10) subject to their PC and AD equations (1-4), and to the aggregate relations. Then, their problem consists in minimizing the loss function

$$\min_{g_1, g_2} \left[L_{EC} = L_F + \frac{1}{2}\pi^2 = \frac{1}{2} \sum_{i=1}^{2} L_{F_i} + \frac{1}{2}\pi^2 = \frac{1}{2} \left[\frac{1}{2} b_y \left(y_1^2 + y_2^2\right) + \frac{1}{2} b_g \left(g_1^2 + g_2^2\right) + \pi^2 \right] \right]$$

The first order condition is:

$$g_1 = -\phi_g^{nc} y_1 - \frac{1}{2} \left[\delta_y \phi_g^{nc} + \frac{b_y}{b_g} \delta_\tau \left(\omega_g + \omega_y \delta_g\right) \right] y_2 - \frac{\omega_g + \omega_y \delta_g}{b_g} \pi. \tag{38}$$

Note that this is similar to country's 1 fiscal rule under fiscal cooperation, FR_1^c, but with an additional term that captures EC's concern about inflation. By symmetry,

the first order condition for country 2 is

$$g_2 = -\phi_g^{nc} y_2 - \frac{1}{2}\left[\delta_y \phi_g^{nc} + \frac{b_y}{b_g}\delta_\tau\left(\omega_g + \omega_y \delta_g\right)\right] y_1 - \frac{\omega_g + \omega_y \delta_g}{b_g}\pi.$$

Aggregating yields

$$g = -\phi_g^c y - \frac{\omega_g + \omega_y \delta_g}{b_g}\pi. \tag{39}$$

The above expression corresponds to the aggregate fiscal rule in the monetary union under enforced fiscal cooperation by the EC. A new trade-off emerges between aggregate fiscal stance and inflation, as a result of fiscal authorities' enforced concern about inflation. The inflation parameter is definitely positive and captures the reaction of aggregate fiscal stance to aggregate inflation variations. This relation is negative, as an increase in inflation generates a decrease in the aggregate fiscal stance. The reaction parameter depends positively upon the effect of each country's change in its fiscal stance upon aggregate inflation, and negatively upon its weight on its fiscal stance. The higher the concern for its fiscal stance relative to aggregate inflation, the lower the inflation reaction parameter will be.

To obtain the final aggregate fiscal rule in the monetary union under EC's enforcement we substitute for union-wide inflation (eq. 5) which results in

$$g = -\phi_g^{ec} y + \frac{1}{2}\left(\omega_g + \omega_y \delta_g\right)\varepsilon_1 \quad : FR^{ec}, \tag{40}$$

where $\phi_g^{ec} = \dfrac{b_g \phi_g^c + \omega_y\left(\omega_g + \omega_y \delta_g\right)}{b_g + \omega_g\left(\omega_g + \omega_y \delta_g\right)}$.

The main difference with the fiscal rule for the standard cooperative case is that fiscal policy must also respond directly to a possible supply shock in country 1. This response is positive, as a positive supply shock reduces inflation and the aggregate fiscal stance must increase. The fiscal reaction parameter, i.e., the parameter of aggregate output, is always positive provided that $\omega_g > 0$. That is, fiscal policy under EC's enforcement is unambiguously countercyclical too.

To compare the magnitude of the fiscal reaction parameter under enforcement with that under the standard cooperative case, we consider

$$\phi_g^{ec} - \phi_g^c = \frac{b_g \phi_g^c + \omega_y\left(\omega_g + \omega_y \delta_g\right)}{b_g + \omega_g\left(\omega_g + \omega_y \delta_g\right)} - \phi_g^c = \frac{\left(\omega_y - \omega_g \phi_g^c\right)\left(\omega_g + \omega_y \delta_g\right)}{b_g + \omega_g\left(\omega_g + \omega_y \delta_g\right)} \gtrless 0. \tag{41}$$

As the sign of the above difference is not clear, we cannot say under which of these two cases fiscal policy is more countercyclical. The answer, however, depends on the sign of a familiar parameter, namely $\omega_y - \omega_g \phi_g^c$. This parameter shows the impact of union-wide output to inflation after taking into account the reaction of the union-wide fiscal stance to output, under standard fiscal cooperation, and its impact on inflation.

Under $\omega_g < 0$, the fiscal reaction parameter for the enforced case is higher than the one for the standard cooperative case if and only if $b_g > |\omega_g| (\omega_g + \omega_y \delta_g)$. If the direct effect of the fiscal stance upon inflation is negative and fiscal authorities care enough about their fiscal stance, then fiscal policy under EC's enforcement will be more countercyclical. If the direct impact of the fiscal stance on inflation is positive ($\omega_g > 0$) two distinct cases emerge. When $\omega_y > \omega_g \phi_g^c$, the direct impact of output upon inflation prevails over the one through fiscal reaction and fiscal policy is more countercyclical than for the standard cooperative case. Alternatively when $\omega_y < \omega_g \phi_g^c$, fiscal reaction prevails, resulting in a less countercyclical fiscal policy with respect to EC's enforcement. Finally, the higher the weight that decentralized fiscal authorities place upon their fiscal stance, the more likely first case becomes. In summary, fiscal policy is less countercyclical if the impact of its fiscal reaction upon inflation is important.

The solutions to the union-wide fiscal stance, output and inflation, as well as for each country, can be computed following the same procedure as for the cooperative case. The solutions are symmetric on the nominal interest rate and on the demand shock to equations (23)-(25), but they also include the supply shock, ε_1. Thus,

$$g^{ec} = \frac{\phi_g^{ec}}{1 - \delta_y + \delta_g \phi_g^{ec}} \delta_r i - \frac{1}{2} \cdot \frac{\phi_g^{ec}}{1 - \delta_y + \delta_g \phi_g^{ec}} u_1 + \frac{1}{2} \cdot \frac{\omega_g + \omega_y \delta_g}{1 - \delta_y + \delta_g \phi_g^{ec}} \varepsilon_1 \tag{42}$$

$$y^{ec} = -\frac{1}{1 - \delta_y + \delta_g \phi_g^{ec}} \delta_r i + \frac{1}{2} \cdot \frac{1}{1 - \delta_y + \delta_g \phi_g^{ec}} u_1 - \frac{1}{2} \cdot \frac{(\omega_g + \omega_y \delta_g) \left(\delta_y - \delta_g \phi_g^{ec}\right)}{\phi_g^{ec} \left(1 - \delta_y + \delta_g \phi_g^{ec}\right)} \varepsilon_1 \tag{43}$$

$$\begin{aligned} \pi^{ec} \quad = \quad & -\frac{\omega_y - \omega_g \phi_g^{ec}}{1 - \delta_y + \delta_g \phi_g^{ec}} \delta_r i + \tfrac{1}{2} \cdot \frac{\omega_y - \omega_g \phi_g^{ec}}{1 - \delta_y + \delta_g \phi_g^{ec}} u_1 - \tfrac{1}{2} \varepsilon_1 \\ & - \tfrac{1}{2} \cdot \frac{(\omega_g + \omega_y \delta_g) \left(\delta_y - \delta_g \phi_g^{ec}\right) \left(\omega_y - \omega_g \phi_g^{ec}\right)}{\phi_g^{ec} \left(1 - \delta_y + \delta_g \phi_g^{ec}\right)} \varepsilon_1 + \tfrac{1}{2} \omega_g \left(\omega_g + \omega_y \delta_g\right) \varepsilon_1 \end{aligned} \tag{44}$$

The analysis with respect to the nominal interest rate and the demand shock is analogous to both the non-cooperative and the standard cooperative cases with the only difference being the supply shock. The solutions for the aggregate fiscal stance and for the output gap are directly related to the supply shock. Under the assumptions in section 4, that $\delta_y < 1 + \delta_g \phi_g^{ec}$ and $\omega_g > 0$, the supply shock is positively related to the aggregate fiscal stance. A positive supply shock that causes aggregate inflation to decrease makes each country's output to decrease as well, triggering an expansionary aggregate fiscal stance. The impact of the supply shock upon aggregate output is more complicated. Under the same circumstances, it also depends upon the impact of aggregate output upon country-specific output, after taking into account the impact of the country-specific fiscal stance on output through the fiscal reaction. If the direct impact dominates ($\delta_y > \delta_g \phi_g^{ec}$), then the output gap responds negatively to a positive supply shock, and vice versa.

9 Monetary Policy Under Enforced Fiscal Cooperation

As equations (42)-(44) reveal, after the monetary policy is set the equilibrium solutions under enforced fiscal cooperation are not symmetric to those under no cooperation and standard cooperation. The common central bank incorporates in its framework the above equations. Being the leader, it minimizes its loss function (eq. 7) with respect to the nominal interest rate and subject to equations (42)-(44), producing the first order condition:

$$y^{ec} = -\phi_{\pi}^{ec}\pi^{ec} \quad : MR^{ec}, \tag{45}$$

where $\phi_{\pi}^{ec} = \dfrac{b_g\left(\omega_y - \omega_g\phi_g^{ec}\right) + a_g\phi_g^{ec}\left(\omega_g + \omega_y\delta_g\right)}{b_g\left(a_y + a_g\phi_g^{c}\phi_g^{ec}\right)}$.

This is the monetary rule in the case of enforced fiscal cooperation. Under $\phi_g^{ec} > 0$, and $\omega_g > 0$, the crucial parameter for understanding the monetary reaction is again $\omega_y - \omega_g\phi_g^{ec}$. In all cases considered fiscal policy is countercyclical and monetary policy depends on how the interest rate finally affects inflation after the fiscal reaction. This holds for non-cooperation, for the benchmark cooperative solution, and for enforced cooperation. If the direct effect of output on inflation dominates ($\omega_y > \omega_g\phi_g^{ec}$) then monetary policy is countercyclical. In contrast, if the indirect effect through the fiscal reaction dominates ($\omega_y < \omega_g\phi_g^{ec}$) monetary policy is procyclical. But this result does not hold strictly under enforced fiscal cooperation.

For monetary policy to be procyclical, the nominator of the monetary reaction parameter has to be negative. In other words, the condition required is

$$\omega_g\phi_g^{ec} > \omega_y + \frac{a_g}{b_g}\left(\omega_g + \omega_y\delta_g\right)\phi_g^{ec}.$$

The second term on the right-hand side of the above inequality captures the impact of the fiscal reaction to inflation multiplied by the fiscal reaction parameter and the weight that the common central bank attaches to the aggregate fiscal stance. This parameter shows the positive impact of fiscal stance upon inflation, whereas the parameter on the left hand side of the inequality captures the prevailing negative impact. In general, enforced fiscal cooperation imposes an additional constraint on monetary policy's procyclicality.

The equilibrium solutions for aggregate output and inflation are:

$$y^{ec} = \frac{1}{2}\cdot\frac{\phi_{\pi}^{ec}\left[1 - \omega_g\left(\omega_g + \omega_y\delta_g\right)\right]}{1 + \phi_{\pi}^{ec}\left(\omega_y - \omega_g\phi_g^{ec}\right)}\varepsilon_1 \tag{46}$$

$$\pi^{ec} = -\frac{1}{2}\cdot\frac{1 - \omega_g\left(\omega_g + \omega_y\delta_g\right)}{1 + \phi_{\pi}^{ec}\left(\omega_y - \omega_g\phi_g^{ec}\right)}\varepsilon_1. \tag{47}$$

Comparing these policy outcomes with those under the non-cooperative or the standard cooperative cases (i.e., equations 32 and 33) reveals that they are not

symmetric. The nominator includes an additional parameter that captures the impact of the fiscal reaction to inflation, $\omega_g(\omega_g + \omega_y\delta_g)$. If this impact is less than unity, and under $\omega_g > 0$, the analysis for the sign of the above solutions are exactly symmetric to the previous cases, whereas if it is greater than unity, the previous analysis is reversed. The impact of the common central bank's fiscal concern parameter on the monetary reaction parameter is ambiguous, depending heavily on the parameterization (For $\frac{\partial \phi_\pi^{ec}}{\partial a_g} > 0$ and under $\omega_g > 0$ it must hold that $a_y(\omega_g + \omega_y\delta_g) > b_y\phi_g^c\left(\omega_y - \omega_g\phi_g^{ec}\right)$) and its stabilization role cannot be easily determined. When this impact is positive, under $\omega_y > \omega_g\phi_g^{ec}$, the fiscal concern parameter facilitates inflation versus output stabilization, and vice versa. When that impact is negative, this result reverses.

10 Conclusion

We analyze a game of monetary leadership in a monetary union when the common central bank is concerned explicitly about the fiscal position of the monetary union's member countries. Our analysis produces a number of results that can be summarized as follows. Given that under a policy leadership game the policy of the follower institution is unambiguously countercyclical, in our monetary leadership model fiscal policy is unambiguously countercyclical. Moreover, cooperative fiscal policy emerges with relatively more pronounced countercyclical features as compared to non-cooperative policy. Monetary policy can be either countercyclical or procyclical, depending on whether the direct effect of output upon inflation or the indirect effect through fiscal reaction dominates. Monetary policy is countercyclical in the first case whereas it is procyclical in the latter case, which is more likely to obtain under fiscal cooperation. The equilibrium solutions for output and inflation depend on the policies' reaction parameters while demand shocks are fully stabilized at the union-wide level. Equilibrium inflation is always negatively related to the supply shocks. Optimal policy, that is fiscal and monetary cooperation, requires monetary policy to be countercyclical and fiscal policy to be procyclical. Under enforced fiscal cooperation, fiscal policy responds positively and in a direct fashion to the supply side shock while fiscal policy is countercyclical under specific conditions. Under enforced fiscal cooperation, monetary policy can be either countercyclical or procyclical, as in the cases of non-cooperation or cooperation, although a countercyclical "bias" exists. The monetary reaction parameter is negatively related to the central bank's weight on the aggregate fiscal stance. It emerges that, under supply shocks, an increase in this weight increases inflation in equilibrium while it decreases the output gap. This is a feature of the decentralized and the standard cooperation cases as well. The central bank's concern about the aggregate fiscal stance facilitates output stabilization and central budget stabilization, but comes at the expense of inflation stabilization. Finally, under enforced fiscal cooperation, the result of a change in the common central bank's weight on the aggregate fiscal stance upon the monetary reaction parameter

is ambiguous, depending on parameter values, and thus its stabilization role cannot be clearly determined.

References

[1] Andersen T. M., 2008. The Macroeconomic Policy Mix in a Monetary Union with Flexible Inflation Targeting. *Journal of International Money and Finance*, 27, pp. 411–37.

[2] Baldwin R., Wyplosz C., 2004. *The Economics of European Integration*. McGraw Hill Education.

[3] Barro R., Gordon D., 1983. A Positive Theory of Monetary Policy in a Natural Rate Model. *Journal of Political Economy*, 91, pp. 589–610.

[4] Beetsma R., Debrun X., 2004. The Interaction between Monetary and Fiscal Policies in a Monetary Union: a Review of Recent Literature [in:] Beetsma R., Favero C., Missale A., Muscatelli A., Natale P., Tirelli P. (eds.) *Monetary Policy, Fiscal Policies and Labor Markets: Macroeconomic Policymaking in the EMU*, Cambridge University Press.

[5] Beetsma R., Bovenberg A. L., 2005. Structural Distortions and Decentralized Fiscal Policies in EMU. *Journal of Money, Credit and Banking*, 37, pp. 1001–18.

[6] Blinder A. S., Mankiw N. G., 1984. Aggregation and Stabilization Policy in a Multi-Contract Economy. *Journal of Monetary Economics*, 13, pp. 67–86.

[7] Buti M., Roeger W., In't Veld J., 2001. Stabilizing Output and Inflation: Policy Conflicts and Co-operation under a Stability Pact. *Journal of Common Market Studies*, 39, pp. 801–28.

[8] Buti M., Van Den Noord P., 2004. Fiscal Policy in EMU: Rules, Discretion and Political Incentives. European Commission, Directorate-General for Economic and Financial Affairs, Economic Paper, No 206.

[9] Clarida R., Gali J., Gertler M., 1999. The Science of Monetary Policy: A New Keynesian Perspective. *Journal of Economic Literature*, 37, pp. 1661–707.

[10] Dixit A., 2001. Games of Monetary and Fiscal Interactions in the EMU. *European Economic Review*, 45, pp. 589–613.

[11] Dixit A., Lambertini L., 2001. Monetary-fiscal Policy Interactions and Commitment versus Discretion in a Monetary Union. *European Economic Review*, 45, pp. 977-87.

[12] Dixit A., Lambertini L., 2003. Interactions of Commitment and Discretion in Monetary and Fiscal Policies. *American Economic Review*, 93, pp. 1522–42.

[13] Gali J., 2008. *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework*. Princeton University Press.

[14] Gatti D., Van Wijnbergen C., 2002. Coordinating Fiscal Authorities in the Euro Zone: A Key Role for the ECB. *Oxford Economic Papers*, 54, pp. 56–71.

[15] Hughes H. A., 2005. In Praise of Fiscal Restraint and Debt Rules: What the Euro Zone Might Do Now. CEPR DP5043.

[16] Kirsanova T., Stehn S. J., Vines D., 2005. The Interactions between Fiscal Policy and Monetary Policy. *Oxford Review of Economic Policy*, 21, pp. 532–64.

[17] Lambertini L., Rovelli R., 2004. Independent or Coordinated? Monetary and Fiscal Policy in EMU [in:] Beetsma R., Favero C., Missale A., Muscatelli A., Natale P., Tirelli P. (eds.): *Monetary Policy, Fiscal Policies and Labor Markets: Macroeconomic Policymaking in the EMU*, Cambridge University Press.

[18] Mundell R. A., 1961. A Theory of Optimum Currency Areas. *American Economic Review*, 51, pp. 657–65.

[19] Rogoff K., 1985. The Optimal Degree of Commitment to an Intermediate Monetary Target. *Quarterly Journal of Economics*, 100, pp. 1169–90.

[20] Svensson L. E. O., 1997. Optimal Inflation Targets, "Conservative" Central Banks, and Linear Inflation Contracts. *American Economic Review*, 87, pp. 98–114.

[21] Uhlig H., 2003. One money, but many fiscal policies in Europe: What are the consequences? [in:] Buti M. (ed.) *Monetary and Fiscal Policies in EMU: Interactions and Coordination*, Cambridge University Press.

[22] Walsh C. E., 2003. *Monetary Theory and Policy*. 2nd edition, MIT Press, Cambridge, MA.