Stabilization and fiscal policy coordination in a heterogeneous monetary union

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juin 2004 - LEO, University of Orleans (France)

Abstract

The aim of this article is to determine whether fiscal policy coordination is desirable regarding the stabilization of supply and demand shocks. We develop a simple two-country model forming a monetary union. Some heterogeneity is introduced since the price stickiness differs across countries. Our results depend crucially on the order of the strategic game between the central bank and the governments. We then show that aggregate income and inflation are always better stabilized with coordination when governments behave as leaders and when structural heterogeneiy exists. Furthermore, the wider the heterogeneity, the more desirable coordination is.

Keywords : fiscal coordination, policy mix, stabilization, monetary union, structural heterogeneity.

JEL Classification : E 58, E 61, E 62 et E 63.

Résumé

Stabilisation et coordination des politiques budgétaires dans une union monétaire hétérogène

L'objectif de cet article est d'évaluer le gain, en termes de stabilisation macroéconomique, apporté par la coordination des politiques budgétaires dans une union monétaire hétérogène. Nous montrons alors que le gain à la coordination dépend de façon cruciale de l'ordre du jeu considéré entre la banque centrale et les gouvernements. Le revenu et l'inflation de l'union sont toujours mieux stabilisés dans un régime de coordination avec gouvernements meneurs dès lors qu'il existe des hétérogénéités structurelles. De plus, l'intérêt de coordonner les politiques budgétaires est croissant avec le degré d'hétérogénéité. .

Mots clés : coordination budgétaire, policy mix, stabilisation, union monétaire, hétérogénéités structurelles.

Classification JEL : E 58, E 61, E 62 et E 63.

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Introduction

Since the beginning of the third stage of the Economic and monetary union, the coordination of economic policies in a monetary union has been a recurring debate[1]. Indeed, the adoption of the common currency and the increasing integration of the goods, financial and monetary markets strengthen existing externalities and create new. Not only is the euro the currency common to twelve member states but now, these countries also have to consider that growth, price stability, financial stability or external balance are common objectives. Naturally, the institutional organization set up by the treaties of Maastricht and Amsterdam is in the core of this issue. Whereas the monetary policy is delegated to a supranational and independent authority, fiscal policies still remain decentralized and rules by the Stability and Growth Pact. The question of the relevance national fiscal policies coordination arises all the more acutely since the very strong independence of the European central bank pushes aside any perspective of an increase in the coordination between monetary policy and fiscal policies.

The requirements of the increasing interdependence in EMU are twofold. First, it calls for a certain degree of fiscal discipline allowing to protect member states from the negative consequences of some economic policy choices. Second, it requires a stronger cooperation to provide a better macroeconomic stabilization[2]. These two points refer to two views of fiscal policy coordination which are not necessarily antinomical.

On the one hand, coordination can be considered as a set of coercitive rules aiming to limit the possible biases of public spending[3]. The Stability and Growth Pact (SGP) follows this line. Indeed, Korkman (2001) considers that the SGP is a tool of fiscal policy coordination insofar as it favours the achievement of a common objective : the stability of prices. From a theoretical point of view, Villieu (2003) shows that the Pact is a *second best* solution allowing to reduce inflationary and public spending biases thanks to the optimal contract, quadratic linearly, would be very difficult to put into practice. Actually, it is not generally the need for fiscal discipline which is controversial but the proper design of the SGP[4].

On the other hand, the fiscal policy coordination can be organized by means of discretionary measures. The aim then becomes macroeconomic stabilization. Which degree of cooperation between fiscal authorities would allow to carry out a better stabilization of shocks in monetary union ? Is cooperation really desirable ? In a configuration where the game of economic policy boils down to the interactions between two governments, the question of the coordination is reduced to a truism. Within the framework of a monetary union, the strategic decisions of the third player, the common central bank, can not be overlooked. The interest of the coordination comes back into question as far as objective conflicts can appear between governments and the central bank. This paper is in

[1]See Mundschenk & von Hagen (2001) for a general thought on this subject.

[2]See Pisani-Ferry (2002).

[3]Put notably in evidence by Chari & Kehoe (1998), Debrun & Wyplosz (1999) or Beetsma & Uhlig (1999).

[4]See Eichengreen & Wyplosz (1998), Mathieu & Sterdyniak (2003) ou Wyplosz (2003).

this perspective and tries to assess if fiscal policy coordination is desirable as regards the macroeconomic stabilization problem, in a heterogeneous monetary union.

We present a model of a closed monetary union with two countries. Prices are imperfectly flexible. Each economy is disturbed by supply and demand shocks whose symmetrical and asymmetrical components we indentify. We suppose that the degree of nominal rigidity is different for each country because of the heterogeneity of types of wage bargaining. So, the union is asymmetrical due to the nature of the shocks which affect the economy and because of different structural characteristics. The model is static which, by construction, pushes aside the problem of excessive debts. Beetsma & Bovenberg (2003) propose an analysis of the debt policy in an heterogeneous monetary union. They show that each country can be encouraged to increase its debt so as to incite the common central bank to bend the monetary policy and thus increase so the seigniorage revenues[5].

In the same way, we do not try to assess if the fiscal policy coordination reduces the inflationary and public spending biases. Indeed, on the one hand, this question refers inevitably to a different conception of coordination dealing with the need for enforceable mechanisms. On the other hand, it was abundantly studied in the literature. Notably, Beetsma & Bovenberg (1998) show that the public spending bias is amplified when fiscal policies are coordinated. Indeed, cooperation increases the strategic power of governments in a sequential game in which they are leaders. This conclusion is nevertheless challenged by Catenaro & Tirelli (2000) which integrate fiscal spillovers into the same model.

Regarding the stabilization of shocks, the common central bank is often considered as having to manage symmetrical shocks whereas national governments would use their fiscal policies to stabilize idiosyncratic shocks. This argument is notably put forward by Korkman (2001) or Uhlig (2002). The latter shows that the optimal *policy-mix* is such that governments cushion national fiscal shocks whereas the central bank handles the supply shocks. Mundschenk & von Hagen (2003) reach the same result when the central bank worries about inflation only. Nevertheless, Uhlig (2002) consider that in a monetary union, the decentralization of fiscal policies leads to a lack of coordination which entail higher interest rates on average. Then, he favours the implementation of a binding rule, such as the Pact, rather than more fiscal policy coordination. On the contrary, Mundschenk & von Hagen (2003) show that fiscal policy coordination is most often beneficial because it allows a better stabilization of shocks. This result is also highlighted by Catenaro & Tirelli (2000) when fiscal spillovers are important. The analysis developed by Beetsma, Debrun & Klaassen (2001) qualifies these conclusions and shows, in a model of monetary union with two countries, that there are configurations in which the coordination of fiscal policies is counter-productive. The gains from coordination then depend on the nature of the economic policy game (simultaneous or sequential game) and on shocks. Villieu (2003), in a n country model, shows paradoxically that the more asymmetrical shocks are important compared to symmetrical shocks, the less necessary the fiscal policy cooperation is when the monetary union enlarge. Laskar (2003) obtains opposite conclusions and coordination

[5]The same arguments can be found, close to the unpleasant monetarist arithmetic of Sargent & Wallace (1981), in Beetsma & Uhlig (1999).

allows a better stabilization when asymmetrical shocks dominate. Consequently, these various results show us how sensitive conclusions stemming from this type of analysis are to the proposed theoretical framework.

Our paper goes on from these recent works and will try to bring a new point of view by considering a heterogeneous monetary union. Indeed, the works carried out before always supposed that countries forming the union were completely identical[6]. However, heterogeneities in the structures of the labour force market and those of the credit market are important[7] and are bound to condition the efficiency of fiscal and monetary policies and, consequently, the interest of fiscal policy coordination. Besides, we consider that it is risky to take a stand on the nature of economic policy game which the European central bank and the national governments are engaged. So, we estimate gains of coordination within the framework of a simultaneous or a sequential game, whether the governments or the central bank play first. So, firstly, we present the framework of analysis. Then, we will study the interest of fiscal policy coordination in a simultaneous game then in a one between the central bank and the fiscal authorities.

1 Description of the model

1.1 Framework

We develop a simple static model[8] of a closed monetary union with two heterogeneous countries, indicated by h and f. Each country produces an imperfectly substitutable good and face supply and demand shocks that can be symmetrical or asymmetrical. In the short run, prices are sticky so that the production level can temporarily deviate from the natural level. The supply functions thus spell :

$$y_h^s = \theta_h \pi_h + \mu_h^s \quad (1)$$
$$y_f^s = \theta_f \pi_f + \mu_f^s \quad (2)$$

where y_j represents the level of production, π_j the rate of inflation and μ_j^s the supply shocks such as $\mu_j^s \sim i.i.d(0, \sigma_{\mu^s}^2)$ with $j = h, f$. Following Ascencio, Blot, Colletaz, Serranito & Villieu (2003), we introduce a source of heterogeneity relative to the degree of nominal rigidity. So, we suppose that the θ_j parameters are different for each country of the union. This assumption reveals the existence of heterogeneity concerning the type of wage bargaining; this phenomenon is notably empirically verified by Cadiou et al. (2000). If we call ε the degree of heterogeneity of the union with $0 < \varepsilon < 1$, we can write :

$$\theta_h = (1 + \varepsilon)\theta$$
$$\theta_f = (1 - \varepsilon)\theta$$

[6]Duchassaing & Koessler (2004) also introduce a structural heterogeneity relative to the interest rate effect on the agregate demand in a two-country model. But they focus rather on information asymmetries and transmission than on coordination problem.

[7]See notably Cadiou, Guichard & Maurel (2000) or Penot (2002).

[8]All the variables are expressed in logarithm except for the interest rate of the union.

where θ represents the average nominal degree of rigidity. Furthermore, for any variable x_j, we can define the aggregate component noted $x = \frac{1}{2}(x_h + x_f)$ and the difference between home and foreign country noted $\bar{x} = \frac{1}{2}(x_h - x_f)$.

The demand functions for each country can be spelt as :

$$y_h^d = g_h + \beta g_f - \gamma\ i + \mu_h^d \quad (3)$$
$$y_f^d = g_f + \beta g_h - \gamma\ i + \mu_f^d \quad (4)$$

So, the demand functions depend on national and foreign fiscal policies g_h and g_f, on the real interest rate[9] noted i and of μ_j^d the demand shocks such as $\mu_j^d \sim i.i.d(0, \sigma^2_{\mu^d})$. Coefficients β and γ are supposed positive.

Consequently, the foreign fiscal policy exerts two types of externalities on national demand. On the one hand, it has a positive and direct demand effect. On the other hand, an expansionist fiscal policy creates inflationist pressures likely to incitate the central bank to raise the interest rate of the union and this increase has a negative impact on domestic income. Concerning the shocks, we call respectively μ_k and $\bar{\mu_k}$ symmetrical and asymmetrical components of shocks with $k = s, d$.

Then, the model can easily be solved by writing the supply and demand aggregated functions and the difference funcitons of supply and demand. We then obtain :

$$y^s = \theta\pi + \theta\varepsilon\bar{\pi} + \mu^s \quad (5)$$
$$\bar{y^s} = \theta\varepsilon\pi + \theta\bar{\pi} + \bar{\mu^s} \quad (6)$$
$$y^d = (1+\beta)g - \gamma\ i + \mu^d \quad (7)$$
$$\bar{y^d} = (1-\beta)\bar{g} + \bar{\mu^d} \quad (8)$$

Equations (7) and (8) directly give solutions for the aggregate income and the deviation of income whereas equations (5) and (6) allow then to obtain the following solutions for the inflation of the union and the differential of inflation :

$$\pi = \omega[(1+\beta)g - \gamma\ i + \mu^d - \mu^s] - \varepsilon\omega[(1-\beta)\bar{g} + \bar{\mu^d} - \bar{\mu^s}] \quad (9)$$
$$\bar{\pi} = -\varepsilon\omega[(1+\beta)g - \gamma\ i + \mu^d - \mu^s] + \omega[(1-\beta)\bar{g} + \bar{\mu^d} - \bar{\mu^s}] \quad (10)$$

with $\omega = \frac{1}{\theta(1-\varepsilon^2)}$ et $\frac{\partial\omega}{\partial\varepsilon} > 0$.

The aggregate income and inflation as well as the differences for income and for inflation are a function of economic policy variables and of symmetrical and asymmetrical components of the supply and demand shocks. Altogether, we find the standard effects of monetary and fiscal policies and of supply and demand shocks. However, let us note that the presence of the structural heterogeneity implies that the inflation of the union also depends on the asymmetrical shocks as well as on the difference between public spendings. In that case, an asymmetrical shock or an increase in the deviation of public spending

[9]Insofar as the problem of inflationary bias is pushed aside, the expected inflation rate is equal to zero and the real or nominal interest rate can thus be used indifferently.

entails a drop in the inflation whereas an asymmetrical supply shock increases aggregate inflation.

1.2 The economic policy game

Economic policies are endogeneous and result from a strategic game between the economic policy authorities. The common and independent central bank sets the union's interest rate whereas each fiscal autority determines its public spending in a non coordinated or in a coordinated way.

The central bank preferences are given by a quadratic loss function noted L^{BC} including the average inflation and the average income of the union. The λ parameter then indicates the relative preference of the central bank for the stabilization of the average income with $y = \frac{1}{2}(y_h + y_f)$ et $\pi = \frac{1}{2}(\pi_h + \pi_f)$:

$$L^{BC} = \frac{1}{2}[(\pi)^2 + \lambda\ (y)^2] \tag{11}$$

The national government preferences are also expressed by a quadratic loss function but it depends on the national income and on the public spending with ψ interpreted as the weight of the fiscal constraint on the loss function[10] :

$$L_j^G = \frac{1}{2}[(y_j)^2 + \psi\ (g_j)^2] \tag{12}$$

We consider a non-cooperative game between the central bank and the governments and we are interested in the relevance of fiscal policy coordination, as regards the stabilization issue, and according to the order of the game. Indeed, there is no consensus on the order of the game between the economic policy authorities. Whereas some authors consider that the authorities play simultaneously[11], others, on the contrary, suppose that authorities commit in a sequantial game in which the governments play as leaders[12]. The latters justify this choice by infering that the governments play first as far as the fiscal decision-making procedures are longer and more complex, whereas the central bank, reacting faster, plays as follower. In other words, they suppose that the governments play first because their ability to react is slower than of the central bank. However, it is rather difficult to consider this argument in a static framework in which authorities play only once. Besides, the order of the game refers to the idea of an informative advantage of one or none of the two players.

[10] We can imagine that the national governments integrate themselves a public spending target or that they are constrained by a fiscal rule imposed by a supranational authority.

[11] See, for example, Villieu (2000) or still Mundschenk & von Hagen (2003) and Laskar (2003).

[12] Like Beetsma & Bovenberg (1998) , Uhlig (2002). Lambertini & Rovelli (2003) show that the authorities are going to prefer a sequential game and, within this framework, governments are more likely to play as leaders.

Nevetheless, in the EMU, it is rather delicate to assert *a priori* that the ECB or national governments could benefit from such an informative advantage. For all these reasons, we chose to run our analysis without taking a stand on the actual order of the game between the governments and the central bank. Consequently, we shall sonsider the three possible configurations of the game and underline the consequences of each considered configuration on strategic interactions among players : the Nash equilibrium (simultaneous decisions) and the Stackelberg equilibria (sequential decisions) with the central bank as leader then with national governments as leaders.

Concerning the fiscal game, we consider that the national governments can play in a non-cooperative or in a cooperative way. So, for each game between the central bank and the governments, we shall consider two fiscal equilibria, whether the national governments decide to coordinate their decisions or not. Without fiscal coordination, each government minimizes its loss function given by the equation (12) without taking into account the effects of its fiscal policy on the other country. On the contrary, with fiscal coordination, the governments minimize a collective loss function given by the equation (13) built as the sum[13] of national loss functions :

$$L^G = L_h^G + L_f^G = \frac{1}{2}[(y_h)^2 + (y_f)^2 + \psi\ (g_h)^2 + \psi\ (g_f)^2] \tag{13}$$

The relevance of fiscal coordination is then estimated in the light of the ability to stabilized the various shocks on the aggregated income and inflation.

2 Equilibrium with simultaneous decisions

When decisions are taken simultaneously, each player determines its optimal behaviour by considering that of the other players as given. We then obtain the expression of the optimal reaction function of the player according to the behaviour of the other players. In this game configuration, which ends in a Nash equilibrium, no player holds privileged information about the game of the other players.

So, the central bank and the national governments minimize simultaneously their respective loss function by considering the behaviour of the other authorities as given.

The central bank minimizes its loss given by equation (11) with regard to the interest rate by considering the national public spending as given :

$$\begin{cases} \underset{\{i\}}{Min}\, L \\ \text{sc } g_h \text{ and } g_f \text{ given} \end{cases}$$

[13] As we suppose that countries are of identical size, the sum is not weighted by the size of each country.

The first-order condition of this optimization program can spell so:

$$\frac{\partial L^{BC}}{\partial i} = 0 \Rightarrow \omega\pi + \lambda y = 0 \tag{14}$$

We then get directly the central bank reaction function giving the expression of the interest rate depending on random shocks and on public spending :

$$\gamma\ i = (1+\beta)g - \varepsilon\phi(1-\beta)\overline{g} + (\mu^d - \phi\mu^s) - \varepsilon\phi(\overline{\mu}^d - \overline{\mu}^s) = \gamma\ i\ (g, \overline{g}) \tag{15}$$

with $\phi = \frac{1}{1+\lambda\ [\theta(1-\varepsilon^2)]^2}$ and $\frac{\partial\phi}{\partial\varepsilon} > 0$..

So, the central bank reacts to cyclical shocks but also to public spending. Indeed, any exogeneous increase of public spending contributes to increasing the income and the inflation of the union. Then, the central bank tightens monetary policy to bring the two objective variables back to their respective target. Let us note that, since the monetary union is heterogeneous ($\varepsilon \neq 0$), the central bank is interested also in the stabilization of asymmetrical shocks as far as these affect average inflation.

Without fiscal coordination, each government minimizes its national loss given by equation (12) with regard to public spending by considering the interest rate and the behaviour of the other government as given :

$$\begin{cases} \underset{\{g_j\}}{Min}\, L_j^G \quad \text{for} \quad j = h, f \\ \\ \text{uc}\ \gamma i \ \text{ and } g_{j'} \ \text{ given } \ \text{ for } \ j' = f, h \end{cases}$$

so, the first-order conditions are the following ones :

$$\frac{\partial L_h^G}{\partial g_h} = 0 \quad \Rightarrow \quad (y + \overline{y}) + \psi(g + \overline{g}) = 0 \tag{16}$$

$$\frac{\partial L_f^G}{\partial g_f} = 0 \quad \Rightarrow \quad (y - \overline{y}) + \psi(g - \overline{g}) = 0 \tag{17}$$

which allows us to obtain the fiscal reaction functions of each government knowing that $g_h = g + \overline{g}$ and $g_f = g - \overline{g}$ with :

$$g \ = \ \frac{\gamma i - \mu^d}{(1+\beta)^2 + \psi} = g_{nc}\ (\gamma i, \overline{g}) \tag{18}$$

$$\overline{g} \ = \ \frac{-\overline{\mu}^d}{(1-\beta) + \psi} = \overline{g}_{nc}\ (\gamma i, g) \tag{19}$$

The Nash equilibrium of such a game without fiscal coordination can be expressed as :

$$y_{nc}^N \ = \ \frac{\varepsilon\ \phi\ \psi}{(1-\beta)+\psi}\ \overline{\mu}^d + \phi\ (\mu^s - \varepsilon\ \overline{\mu}^s) \tag{20}$$

$$\pi_{nc}^N \ = \ -\lambda\theta(1-\varepsilon^2)\ y \tag{21}$$

$$g_{nc}^N \ = \ -\frac{\varepsilon\ \phi}{(1-\beta)+\psi}\ \overline{\mu}^d - \frac{\phi}{\psi}\ (\mu^s - \varepsilon\ \overline{\mu}^s) \tag{22}$$

$$\gamma i_{nc}^N \ = \ \mu^d - \frac{(1+\beta)+\psi}{(1-\beta)+\psi}\ \varepsilon\ \phi\ \overline{\mu}^d - \frac{(1+\beta)+\psi}{\psi}\ \phi\ (\mu^s - \varepsilon\ \overline{\mu}^s) \tag{23}$$

Income, inflation, interest rates and average public spending depend on asymmetrical demand shocks and on supply schocks. Let us note here that the symmetrical demand shocks are perfectly stabilized by the central bank and so have no effect on average income and average inflation. Whatever the considered game is, aggregated variables are always going to depend on the same shock structure. Only elasticities in shocks differ according to the nature of the game. It should be pointed out that the introduction of a structural heterogeneity is not neutral from the point of view of the optimal *policy-mix*. Indeed, Mundschenk & von Hagen (2003) obtain a distribution in which the central bank takes care of the stabilization of demand shocks and the national governments handle that of supply shocks. Here, there isn't any specialization except for the symmetrical demand shocks totally controlled by the common central bank. The stabilization of asymmetrical demand shocks and supply shocks is controlled by the national governments and the central bank. Whithout heterogeneousness ($\varepsilon \to 0$), average variables depend only on symmetrical shocks.

With fiscal coordination, governments minimize the collective loss given by equation (13) with regard to public spending by considering the interest rate given :

$$\begin{cases} \underset{\{g_h, g_f\}}{Min}\ L^G \\ \\ \text{uc } \gamma i \ \text{ given} \end{cases}$$

so we can deduct the first-order conditions :

$$\frac{\partial L^G}{\partial g_h} = 0 \quad \Rightarrow \quad (1+\beta)\ y + (1-\beta)\ \overline{y} + \psi(g + \overline{g}) = 0 \tag{24}$$

$$\frac{\partial L^G}{\partial g_f} = 0 \quad \Rightarrow \quad (1+\beta)\ y - (1-\beta)\ \overline{y} + \psi(g - \overline{g}) = 0 \tag{25}$$

which enables us to obtain the fiscal reaction functions :

$$g \ = \ \frac{(1+\beta)\ (\gamma i - \mu^d)}{(1+\beta)^2 + \psi} = g_c\ (\gamma i, \overline{g}) \tag{26}$$

$$\overline{g} \ = \ \frac{-(1-\beta)\ \overline{\mu}^d}{(1-\beta)^2 + \psi} = \overline{g}_c\ (\gamma i, g) \tag{27}$$

The Nash equilibrium of such a game with fiscal coordination can be expressed as :

$$y_c^N \ = \ \frac{\varepsilon\ \phi\ \psi}{(1-\beta)^2 + \psi}\ \overline{\mu}^d + \phi\ (\mu^s - \varepsilon\ \overline{\mu}^s) \tag{28}$$

$$\pi_c^N \ = \ -\lambda\theta(1-\varepsilon^2)\ y \tag{29}$$

$$g_c^N \ = \ -\frac{\varepsilon\ \phi\ (1+\beta)}{(1-\beta)^2 + \psi}\ \overline{\mu}^d - \frac{\phi\ (1+\beta)}{\psi}\ (\mu^s - \varepsilon\ \overline{\mu}^s) \tag{30}$$

$$\gamma i_c^N \ = \ \mu^d - \frac{(1+\beta)^2 + \psi}{(1-\beta)^2 + \psi}\ \varepsilon\ \phi\ \overline{\mu}^d - \frac{(1+\beta)^2 + \psi}{\psi}\ \phi\ (\mu^s - \varepsilon\ \overline{\mu}^s) \tag{31}$$

The *comparison of these two regimes*[14] *(without and with fiscal coordination)*, enables us to show that, when the authorities set the level of their instrument simultaneously and with fiscal coordination, income but also inflation are more sensitive to asymmetrical demand shocks and the fiscal coordination has no effect on the stabilization of supply shocks. In other words, in this game configuration, fiscal coordination, which comes along with a larger volatility of public spending, turns out to be counter-productive. It destabilizes macroeconomic variables (activity and inflation). As for symmetrical demand shocks, they are perfectly stabilized whatever the considered regime is. This stabilization is perfectly taken care of by the central bank[15].

Besides, we can notice that without structural heterogeneity, the non cooperative and cooperative equilibria are similar. This element is thus determining as regards the interest of fiscal coordination. In the same way, we can show directly that the stabilization of the various macroeconomic variables is identical when the constraint bearing on public spending is very strong ($\psi \to \infty$). In that particular case, public spending is always equal to the target and only the common central bank takes care of the stabilization of various shocks.

3 Equilibrium with sequential decisions

Now, we consider a game with sequential decisions between the central bank and the national governments. In this Stackelberg-type game, one of the players acts as « leader » and, consequently, the others play as « followers ». A leader's position enables the concerned player to determine its behaviour before the other players while knowing perfectly the way which are going to play the other players. From then on, the leader has privileged information on the behaviour of its competitors. As a consequence, it is going to be able to exploit this information to determine its optimal behaviour. Conversely, the follower has only to adapt to the behaviour of the leader. In other words, the follower is constrained by the behaviour of the leader.

To obtain the equilibrium in this Stackelberg game, we must first determine the follower's reaction functions. Indeed, as any game with sequential decisions, the resolution takes place backwards. From then on, we first have to determine the reaction functions of the followers to be able to introduce them into the leader's optimization program. Then, we shall be able to solve the leader's program and so to determine the equilibrium according to the considered informational situation.

[14] The gains of fiscal coordination are estimated by comparing the sensitivity (or variance) of the aggregate income and inflation according to the various sources of shocks. The differences in sensitivity are generally obtained directly, so we chose not to detail calculations.

[15] We shall notice afterward that this result is also verified for all others considered configurations of game.

3.1 Central bank as leader

When the central bank is a leader, it determines the optimal interest rate which minimizes loss under the constraint of the national reaction function. This position allows it not to be forced by the behaviour of the national governments but, on the contrary, to impose the decision on them. Within the framework of the EMU, it means considering that the national governments have to adapt to the policy of the central bank.

Without fiscal coordination, the central bank minimizes its loss function with regard to the interest rate under the constraint of the national reaction functions given by equations (18) and (19) :

$$\begin{cases} \underset{\{i\}}{Min}\, L \\ \text{uc } g_{nc}\ (\gamma i, \overline{g}) \ \text{ and } \ \ \overline{g}_{nc}\ (\gamma i, g) \end{cases}$$

The first-order condition can be expressed as :

$$\frac{\partial L^{BC}}{\partial i} = 0 \Rightarrow \omega\pi + \lambda y = 0 \tag{32}$$

and we can obtain the optimal interest rate in the union and the Stackelberg equilibrium of this game with central bank as leader and without fiscal coordination :

$$y_{nc}^{Sb} = \frac{\varepsilon\ \phi\ \psi}{(1-\beta)+\psi}\ \overline{\mu}^{d} + \phi\ (\mu^{s} - \varepsilon\ \overline{\mu}^{s}) \tag{33}$$

$$\pi_{nc}^{Sb} = -\lambda\theta(1-\varepsilon^{2})\ y \tag{34}$$

$$g_{nc}^{Sb} = -\frac{\varepsilon\ \phi}{(1-\beta)+\psi}\ \overline{\mu}^{d} - \frac{\phi}{\psi}\ (\mu^{s} - \varepsilon\ \overline{\mu}^{s}) \tag{35}$$

With fiscal coordination, the central bank proceeds in the same way but under the constraint of the cooperative fiscal reaction functions given by equations (26) and (27) :

$$\begin{cases} \underset{\{i\}}{Min}\, L \\ \text{uc } g_{c}\ (\gamma i, \overline{g}) \ \text{ and } \ \ \overline{g}_{c}\ (\gamma i, g) \end{cases}$$

Starting from the first-order condition we express the Stackelberg equilibrium of this game with central bank as leader and with fiscal coordination :

$$y_{c}^{Sb} = \frac{\varepsilon\ \phi\ \psi}{(1-\beta)^{2}+\psi}\ \overline{\mu}^{d} + \phi\ (\mu^{s} - \varepsilon\ \overline{\mu}^{s}) \tag{36}$$

$$\pi_{c}^{Sb} = -\lambda\theta(1-\varepsilon^{2})\ y \tag{37}$$

$$g_{c}^{Sb} = -\frac{\varepsilon\ \phi\ (1+\beta)}{(1-\beta)^{2}+\psi}\ \overline{\mu}^{d} - \frac{\phi\ (1+\beta)}{\psi}\ (\mu^{s} - \varepsilon\ \overline{\mu}^{s}) \tag{38}$$

The *comparison of these two regimes (without and with fiscal coordination)*, enables us to notice very quickly that such a game configuration ends in the same equilibrium as

when the authorities play simultaneously. As a consequence, the first-mover advantage the central bank benefits does not bring it to modify the monetary strategy. Macroeconomic equilibrium is thus the same as that obtained by the Nash solution. Therefore conclusions on the relevance of fiscal coordination are identical. Indeed the informationnal structure is an advantage only when the model exhibits a conflict about objectives, that is when the two players react differently to the same shock. This is generally the case with supply shocks since they raise output but reduce inflation and when central bank is more conservative than governments. Therefore the leader by taking the others players' strategy into account constrains their response. In our case, governments only care about national output and public expenditures and then react to supply shocks indirectly through the interest rate set by the common central bank. Governments don't consider the central bank's decision rule when they behave as followers. Thereby no conflict about objectives appears and the central bank cannot benefit from the first-mover advantage. Actually, only the governments can strategically exploit the informationnal advantage when they play first.

3.2 Governments as leaders

When the national governments are leaders, they determine their optimal public spending under the constraint of the central bank reaction function. Governments are then free to set their public spending while the central bank has to adapt to their behaviour. Within the framework of the EMU, it means considering that the ECB is constrained by national fiscal policies. Here, governments will benefit from the infomationnal advantage as they will anticipate the interest rate's response to shocks.

Without fiscal coordination, each government minimizes its loss function with regard to public spending under the constraint of the monetary reaction function given by equation (15) and by considering the behaviour of the other government as given. In such a situation, each government does not consider the effects of its fiscal policy on the other country, that is it does not internalize the fiscal spillovers in the union. Then the program can be written:

$$\begin{cases} \underset{\{g_j\}}{Min}\, L_j^G \quad \text{for} \quad j = h, f \\ \\ \text{uc } \gamma\ i = \gamma\ i\ (g, \overline{g}) \quad \text{et } g_{j'} \quad \text{given} \quad \text{for} \quad j' = f, h \end{cases}$$

The first-order conditions are the following :

$$\frac{\partial L_h^G}{\partial g_h} = 0 \quad \Rightarrow \quad (1-\beta)\ (1+\varepsilon\ \phi)\ (y+\overline{y}) + 2\psi(g+\overline{g}) = 0 \tag{39}$$

$$\frac{\partial L_f^G}{\partial g_f} = 0 \quad \Rightarrow \quad (1-\beta)\ (1-\varepsilon\ \phi)\ (y-\overline{y}) + 2\psi(g-\overline{g}) = 0 \tag{40}$$

which give us the Stackelberg equilibrium of this game without fiscal coordination :

$$y_{nc}^{Sg} = \frac{2\ \varepsilon\ \phi\ \psi\ \overline{\mu}^d + [2\ \psi + (1-\beta)^2]\ \phi\ (\mu^s - \varepsilon\ \overline{\mu}^s)}{2\ \psi + (1-\beta)^2\ [1 + (\varepsilon\ \phi)^2]} \tag{41}$$

$$\pi_{nc}^{Sg} = -\lambda\theta(1-\varepsilon^2)\ y \tag{42}$$

$$g_{nc}^{Sg} = -\frac{2(1-\beta)\varepsilon\phi\overline{\mu}^d + \frac{(1-\beta)}{2\psi}[2\psi + (1-\beta)^2[1-(\varepsilon\phi)^2]]\phi(\mu^s - \varepsilon\ \overline{\mu}^s)}{2\psi + (1-\beta)^2\ [1 + (\varepsilon\phi)^2]} \tag{43}$$

With fiscal coordination, governments henceforth minimize the collective loss function :

$$\begin{cases} \underset{\{g_h, g_f\}}{Min}\ L^G \\ \\ \text{sc } \gamma\ i = \gamma\ i\ (g, \overline{g}) \ \text{ donné} \end{cases}$$

The first-order conditions are :

$$\frac{\partial L^G}{\partial g_h} = 0 \ \Rightarrow\ (1-\beta)\ (\varepsilon\ \phi\ y + \overline{y}) + \psi(g + \overline{g}) = 0 \tag{44}$$

$$\frac{\partial L^G}{\partial g_f} = 0 \ \Rightarrow\ (1-\beta)\ (\varepsilon\ \phi\ y + \overline{y}) + \psi(g - \overline{g}) = 0 \tag{45}$$

and the Stackelberg equilibrium with fiscal coordination :

$$y_c^{Sg} = \frac{\varepsilon\ \phi\ \psi\ \overline{\mu}^d + [\psi + (1-\beta)^2]\ \phi\ (\mu^s - \varepsilon\ \overline{\mu}^s)}{\psi + (1-\beta)^2\ [1 + (\varepsilon\ \phi)^2]} \tag{46}$$

$$\pi_c^{Sg} = -\lambda\theta(1-\varepsilon^2)\ y \tag{47}$$

$$g_c^{Sg} = 0 \tag{48}$$

The *comparison of the two regimes (without and with coordination)* shows that coordination always improves the stabilization of asymmetrical demand shocks and also that of supply schocks. Besides, without heterogeneousness ($\varepsilon = 0$), there is no interest in the fiscal coordination, on the one hand because asymmetrical shocks no longer have any incidence on the equilibrium, on the other hand because the effect of symmetrical shocks is identical without or with fiscal coordination. In the same way, there is no opportunity to coordinate national fiscal policies when public spending are strictly constrained ($\psi \to \infty$). The stabilisation of agregate revenue and inflation is always weaker and equal across the two regimes. Consequently, whatever the order of the game, we reach the same conclusions for these two particular cases. Finally, the coordination solution is more desirable as structural heterogeneity increases[16].

[16]See the appendix for details. Coordination becomes also more desirable for asymmetric demand shocks when ψ increases but the relation is much less clear-cut with supply shocks.

Concluding remarks

The aim of this paper was to analyse the desirability of fiscal coordination when viewed from the perpective of macroeconomic stabilization in a heterogeneous monetary union. The coordination desirability was then assessed according to the shocks and to the order of the economic policy game. First, the common central bank always completely cope with symmetric demand shocks. Regarding the others shocks, coordination is desirable only when governments behave as leaders. Otherwise, coordination is likely to be couterproductive. Furthermore, contrary to Laskar (2003) who shows that coordination is better for asymmetric shocks, we find out that it can be desirable even for symmetric supply and demand shocks. However, the gains of coordination depend particularly on the economic policy game rather than on the nature of the shocks hitting countries. This conclusion is closed to the one reached by Beetsma et al. (2001).

Second, the introduction of structural heterogeneity has important implications regarding the optimal policy-mix and the desirability of coordination. Indeed, the common central bank takes care about symmetric and asymmetric shocks when the monetary union is heterogeneous. There is consequently no particular specialization between the common central bank and the national governments regarding the stabilization problem. Then, whatever the timing decisions, cooperative and non cooperative solutions are identical when there is no structural heterogeneity. Finally, when governments play as leaders, the cooperative solution is more desirable as structural heterogeneity increases.

We would like to remind the model's simplicity and point out that the main conclusions crucially rely on the particular hypothesis considered here. We could have contemplate to add others sources of structural heterogeneities. Otherwise, the way the loss functions are defined and the particular variables which governements or central bank take care of are always a point of discussion. Nevertheless, even a marginal change in the structure of the model gives very poorly tractable solutions. So, it would have been very hard to draw any conclusion and interpretation. Alternative hypothesis should certainly be considered in future researchs to check the robustness of our results.

Appendix

Let us note S^d the ratio of elasticities of revenue to asymmetrics demand shocks :

$$S^d = \frac{2\psi + 2(1-\beta)^2\ [1 + (\varepsilon\phi)^2]}{2\psi + (1-\beta)^2\ [1 + (\varepsilon\phi)^2]} = \frac{2\psi + 2g(\varepsilon,\beta)}{2\psi + g(\varepsilon,\beta)}$$

and S^s the ratio of elasticities of revenue to supply shocks :

$$S^s = \frac{2\psi + (1-\beta)^2}{\psi + (1-\beta)^2}\ \frac{\psi + (1-\beta)^2\ [1 + (\varepsilon\phi)^2]}{2\psi + (1-\beta)^2\ [1 + (\varepsilon\phi)^2]} = \frac{2\psi + (1-\beta)^2}{\psi + (1-\beta)^2}\ \frac{\psi + g(\varepsilon,\beta)}{2\psi + g(\varepsilon,\beta)}$$

with $g(\varepsilon,\beta) = (1-\beta)^2\ [1 + (\varepsilon\phi)^2]$.

Impact of an increase in structural heterogeneity (ε) on S^d and S^s :

$$\begin{aligned}
\frac{\partial S^d}{\partial \varepsilon} &= \frac{2\psi}{[2\psi + g(\varepsilon,\beta)]^2}\,\frac{\partial g(\varepsilon,\beta)}{\partial \varepsilon} > 0 \\
\frac{\partial S^s}{\partial \varepsilon} &= \frac{2\psi + (1-\beta)^2}{\psi + (1-\beta)^2}\,\frac{\psi}{[2\psi + g(\varepsilon,\beta)]^2}\,\frac{\partial g(\varepsilon,\beta)}{\partial \varepsilon} > 0 \\
\text{with } \frac{\partial g(\varepsilon,\beta)}{\partial \varepsilon} &= 2\phi\varepsilon\phi(1-\beta)^2 > 0.
\end{aligned}$$

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