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Monetary and Fiscal Policies Interaction in Monetary Unions

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Abstract. In this paper, the literature on the interaction between monetary and fiscal policies in a monetary union is surveyed. By adopting the concept of symbiosis as a starting point, the paper highlights the importance of uncertainty, policy makers' preferences and targets. Then, the role of commitment to policy rules and coordination is addressed. The analysis also focuses on the importance of the data considered for the generation of the policy mix. As a final step, the paper discusses the main results in the literature on public debt management in a monetary union. All the reported theoretical results are then adopted to retrieve policy and institutional implications for the European Monetary Union.

Keywords: Economic shocks; EMU; Monetary and fiscal policies interaction; Monetary union; Policy mix

1 Introduction

With the beginning of European Monetary Union (EMU), a vast literature has adapted macroeconomic theories to analyze various policy design issues in multi-country frameworks. Among these, one of the most relevant is the study of the interaction between a centralized monetary policy and many decentralized fiscal policies. As easily predictable, this literature had its most flourishing period in the beginning of the 2000s. Nevertheless, the global financial crisis, the macroeconomic imbalances within the EMU and the sovereign debt crisis in some member countries have raised questions concerning the targets of the ECB, the degree of policy coordination within the EMU, the enforcement of fiscal rules and the commitment of policy makers to their assigned objectives. This has prompted a renewed interest in the theoretical literature studying monetary and fiscal policies interactions in a monetary union, as it provides possible

answers to such questions and permits to evaluate the ongoing process of redesigning the institutional structure underlying the formation of the policy mix in the EMU.

This paper aims at analyzing the most relevant aspects concerning the interaction between monetary and fiscal policies in a monetary union in order to highlight their policy and institutional implications for the set-up of a well-designed currency union.

The studies that have analyzed the literature on monetary and fiscal policies interaction so far have focused mainly on the case of a stand-alone country and have, sometimes, analyzed multi-country arrangements only as a special case (see for instance Canzonieri *et al.*, 2011). It has to be noted, however, that the problems concerning the policy mix in a monetary union are for large part different from the case of a stand-alone country. Beetsma and Debrun (2004) present a review of the literature on the interaction between monetary and fiscal policies in a monetary union stressing that *"...given the vast and fast expanding literature on the topic, it is impossible to be exhaustive in any discussion"*.

Therefore, in this paper, the selective review on the topic is presented paying more attention to the recent developments in the literature and focusing on some relevant aspects that are not covered in previous studies. Nevertheless, some overlaps necessarily occur in order to allow a self-consistent discussion of the topic.

First, the paper presents a generic theoretical framework that is the cornerstone for setting up an interaction model between monetary and fiscal authorities in a monetary union, and it is therefore able to encompass and generalize most of the modeling solutions established in the literature. Then, based on different specifications of the general theoretical framework, the paper highlights how uncertainty, policy makers' preferences and targets play a crucial role in the determination of the policy mix outcome. Subsequently, the role of commitment to policy rules and coordination among policy makers is studied. The analysis also focuses on the importance of the data (national and union-wide) considered for the generation of the policy mix. Then, as the last step of the analysis, the paper discusses the management of public debt and the risks of insolvency in a monetary union. The presentation of these aspects has been designed also with the aim to provide the reader with a broad range of modeling solutions without compromising the level of homogeneity of the analysis. The reported theoretical results are also used in order to retrieve policy and institutional implications for the EMU.

The paper is organized as follows. Section 2 presents the generic theoretical framework for the analysis of the interaction between monetary and fiscal authorities in a monetary union. Sections 3 to 7 retrieve the solutions of the models under different assumptions and specifications in order to reproduce and discuss the main results in the literature. Section 8 concludes the paper.

2 The Common Framework

As argued by Davig and Gürkaynak (2015), central banks have been increasingly considered as residual claimants of policy. This means that, on top of their usual task of controlling inflation, central banks have been charged with additional policy duties

not fully addressed by other policy makers. According to the authors, this is also the result of the excessive focus on optimal monetary policy, rather than on the optimal policy mix. However, the central bank, with its single policy instrument, cannot control the multiple inefficiencies that characterize the economy as these inefficiencies require multiple policy makers with multiple objectives. Therefore, in order to reduce the likelihood of ill designed policies and institutions, theoretical modeling should focus on the optimal policy mix and on the interaction between fiscal and monetary authorities.

In a monetary union, such interaction is commonly modeled following a simple game theory approach in which monetary policy is conducted by a central bank, while fiscal policy is fractionated among the governments of each member country. Their preferences can be represented as:

$$L_M = h(z_M) \tag{1}$$

$$L_{F,i} = g(z_F) \tag{2}$$

where Equation (1) represents the loss function of the central bank. Assuming that the monetary union is formed by n member countries, Equation (2) represents their governments' loss functions with $i \in \{1, ...,\text{n}\}$. z_M and z_F are the sets of relevant variables for the authorities, which are not necessarily the same for the central bank and the governments. Despite the fact that large part of the literature strictly focuses on the interaction between fiscal and monetary authorities, in addition to these economic agents some studies also consider private agents' behaviour. In this case, the preferences of the representative agent j in country i can be added to the model by means of a payoff function:

$$U_{j,i} = q(z_J) \tag{3}$$

Again, z_J is the set of relevant variables for the representative private agent. All the players optimize their objective function with respect to the variable they directly control[1] subject to a set of constraints $\mathbb{Z}$, linking the variables in z_M, z_F and z_J and representing the surrounding economic scenario. Large part of the literature specifies the interaction game in a linear-quadratic form, meaning that the functional form for the players' payoffs (h, g and q) is quadratic, while $\mathbb{Z}$ is a set of linear equations. When the model is specified on the basis of Equations (1) and (2), it allows only for fiscal spillovers in the monetary union, while the extended version, including also Equation (3), allows taking into account also possible spillovers between private agents.

Assuming simultaneous choices, the solutions of the optimization problems in the extended model provide the best reaction functions for the central bank (CB^{rf}), for the governments (G_i^{rf}) and for the private agents (PA_{ji}^{rf}):

$$CB^{rf} = \chi(z_M, z_F, z_J) \tag{4}$$

$$G_i^{rf} = \zeta(z_M, z_F, z_J) \tag{5}$$

$$PA_{ji}^{rf} = \xi(z_M, z_F, z_J) \tag{6}$$

The set of Equations (4) and (5) represents how each policy authority reacts in response to the others' economic policy maneuvers and to the changes in the economic scenario.

The equilibrium of the game is then obtained solving the system formed by the best reaction functions of all the players. Moreover, the evaluation of the aggregate payoff function (3) at the equilibrium can be adopted in order to assess the welfare implications of alternative policies interactions. When the model does not directly involve private agents, social welfare is measured by a micro-founded social loss function (see for instance Dixit and Lambertini, 2003b; Lambertini, 2006; Galí and Monacelli, 2008; and Ferrero, 2009). As in most of the cases this function results in a combination of (1) and (2) (see Lambertini and Rovelli, 2004; Cavallari and Di Gioacchino, 2005), the total social welfare can also be addressed by measuring the authorities' loss at the equilibrium. This is the welfare criterion adopted in this paper.

3 Symbiosis of Fiscal and Monetary Policies, Preferences and Uncertainty

The starting point to analyze the main results in the literature is the concept of symbiosis between monetary and fiscal authorities that has been introduced by Dixit and Lambertini (2001 and 2003a). Symbiosis implies that if the authorities share the same preferences, the targets can always be attained independently of the details of the institutions. The central bank's loss function can be written as:

$$L_M = \frac{1}{2}(\pi - \pi^M)^2 + \frac{1}{2}\sum_{i=1}^{n} \beta_i^M (y_i - y_i^M)^2 \tag{7}$$

where π is the inflation rate and it is assumed to be unique in the whole union, π^M is the central bank's inflation target, y_i is the output level in each country, and y_i^M represents the output targets of the central bank for each member country. The parameter β_i^M represents the relative weight that the monetary authority assigns to the stabilization of output (in each member country) with respect to the stabilization of inflation. Following the same line, the loss function of the government in country i can be written as:

$$L_{F,i} = \frac{1}{2}(\pi - \pi_i^F)^2 + \frac{1}{2}\beta_i^F (y_i - y_i^F)^2 \tag{8}$$

where π_i^F and y_i^F are, respectively, the targets of inflation and output for government

i, while β_i^F represents the government's preference for output stabilization.
It is assumed that policy makers do not face any kind of uncertainty. Moreover, each country's fiscal policies inflict externalities on other countries, and the common monetary policy has its time-consistency problem. Then, the economy is modeled with the following set of equations:

$$y_i = \overline{y}_i + \sum_{w=1}^{n} k_{iw} f_w + b_i(\pi - \pi^e) \tag{9}$$

$$\pi = \pi_0 + c \sum_{i=1}^{n} f_i \tag{10}$$

Equation (9) represents the determination of the output in each country. In this equation $\overline{y}_i$ can be interpreted as natural level of output in country i, k_{iw} is the parameter of the effects on the output of country i's fiscal policy (f_w with $w = i$) and (for $w \neq i$) it also represents the spillovers effects from other countries' fiscal maneuvers. The parameter b_i reflects the sensitivity of the output to the gap between observed inflation and its expectations (π^e). Equation (10) explains how the common level of inflation is determined in the union[2]. It is based on the assumption that inflation is a sum of the component π_0, which represents its part controlled by monetary policy, and a further contribution arising from national fiscal policies according to the parameter c[3].

Under a similar specification, Dixit and Lambertini (2003a) show that with identical output and inflation targets, there is a mutually beneficial interaction, defined in the literature as a symbiosis between monetary and fiscal policies. As a result of this symbiosis the common targets of inflation and output are always attained. To show this result, it is necessary to assume that the targets are the same for each authority:

$$\pi^M = \pi_i^F = 0, \quad y_i^M = y_i^F = y^T \quad \forall i. \tag{11}$$

According to this specification, the targets of all the authorities coincide and, for the sake of simplicity, it is assumed that the common inflation target is zero. In this specification of the model, the n fiscal authorities and the common central bank act simultaneously and non-cooperatively. The central bank minimizes L_M choosing π_0 and takes f_i as given. Each government i sets its fiscal policy f_i in order to minimize $L_{F,i}$, taking π_0 and all other fiscal choices f_w (with $w \neq i$) as given. All the authorities minimize their loss functions subject to Equations (9) and (10), therefore the first order condition for the central bank is:

$$\sum_{i=1}^{n} \beta_i^M (y_i - y^T) b_i + \pi = 0 \tag{12}$$

While the first order condition for each fiscal authority is:

$$\beta_i^F(y_i - y^T)(k_{ii} + cb_i) + c\pi = 0 \tag{13}$$

The system represented by Equations (12) and (13) has its unique (Nash) equilibrium solution with $y_i = y^T$ for all i and $\pi = 0$. This implies that the solution of the game is obtained when the output and the inflation attain their target levels ($\pi^* = 0$ and $y^* = {y_i}^T$). Moreover, by plugging this solution into Equations (7) and (8) it can be shown that it is ideal for all the authorities as it implies that their bliss points are all achieved ($L_M^{sym} = L_{F,i}^{sym} = 0, \forall i$). The same result can be obtained in an extended version of this model considering also private agents. Kempf and von Thadden (2013) prove this by adding to this model a private agents' payoff function $U = -\frac{1}{2}(\pi - \pi^e)^2$. Also in this case, symbiosis provides the best possible equilibrium, as the bliss points of all players are achieved ($L_M^{sym} = L_{F,i}^{sym} = U^{sym} = 0, \forall i$). The most important feature of symbiosis is that the social optimum is obtained despite disagreements about the weights of the objectives, despite the order of moves, without coordination and irrespective of commitment to policy rules as the analysis of all other equilibria follows the same lines and all yield the common ideal outcome (see Dixit and Lambertini, 2003a). In relation to coordination and commitment, Kempf and von Thadden (2013) define this result as the irrelevance proposition.

Therefore, according to symbiosis, the only relevant aspect is the concordance on the targets between the authorities. Once the concordance is achieved, these targets will be naturally attained irrespectively of any other institutional structure. This offers very appealing theoretical elements for the institutional architecture of a monetary union, and it suggests that most of the main concerns for the EMU may be irrelevant. The Maastricht Treaty and the Stability and Growth Pact (and further reforms) restrain fiscal policies in order to impose a certain level of coordination and minimize the impact of externalities. Moreover, symbiosis also suggests that a strictly committed central bank, like the ECB, seems to be unnecessary as well. According to the results reported, these limitations should not be needed. Obviously this conclusion would be relevant for the EMU only if symbiosis between national governments and the ECB holds.

Unfortunately, symbiosis holds only under some essential features of the model. In the model presented, the authorities share the same variables in their loss functions and they agree on the most desirable level of output in each country and on the most desirable level of inflation. Moreover, it has been assumed that all the shocks are observed and that authorities do not face any type of uncertainty. Therefore, these assumptions can be relaxed in order to elucidate their role.

The assumption of the lack of uncertainty is very important in order to obtain a symbiosis between fiscal and monetary policy. It is worth noting that, due to the linear-quadratic nature of the game, the introduction of unobserved additive shocks into Equations (9) and (10) does not affect the optimal policies set under average outcomes. Nevertheless, multiplicative (or parameter) uncertainty can affect the symbiosis in the strategic interaction between fiscal and monetary authorities. Multiplicative (or parameter) uncertainty imposes a stochastic nature on one or more

of the parameters in the model (see Holly and Hughes Hallett, 1989). Di Bartolomeo and Giuli (2011) and Di Bartolomeo *et al.* (2009) assume that the authorities set their policies on the basis of the model formed by Equations (7)-(10), but they are aware that uncertain deviations from this model can occur[4]. Under this assumption, the model becomes stochastic and multiplicative uncertainty is implemented. In order to analyze the effects of multiplicative uncertainty, the only modification to the model regards Equation (10), that should be rewritten as:

$$\pi = \upsilon\pi_0 + \mu c \sum_{i=1}^{n} f_i \tag{14}$$

According to Equation (14), policy uncertainty is introduced with the assumption that policy makers may not have full knowledge of the effects of their instruments on the level of inflation. Therefore, they do not exactly know the value of some parameters, as only the distributions of these parameters are known. This is introduced in the model with the fact that unobserved shocks can affect fiscal (μ) and monetary (υ) policy effectiveness. The stochastic nature of shocks is modeled as follows: $\mu \sim (1, \sigma_\mu^2)$ and $\upsilon \sim (1, \sigma_\upsilon^2)$. Di Bartolomeo and Giuli (2011) assume that $\mu = 1$ and explore the case of uncertainty about the parameters of the monetary policy effectiveness. They show that in the absence of uncertainty ($\sigma_\upsilon^2 = 0$) symbiosis holds and the targets are attained ($y^* = y^T$ and $\pi^* = 0$). On the contrary, under multiplicative uncertainty ($\sigma_\upsilon^2 \neq 0$) the achievement of ideal output and inflation is not guaranteed anymore. An increasing level of uncertainty raises inflation and reduces output. In the absence of uncertainty, the common targets are always obtained and coordination is not relevant because there is only one policies combination that guarantees the achievement of the shared targets. The explanation for this result is that when outcomes are random, a conflict between policy makers emerges because their targets on average are no longer a common objective. Average outcomes are optimal for the fiscal authorities that do not face any uncertainty, but they are not optimal for the central bank. The conflict also implies that the Nash equilibrium is no longer efficient and coordination between policy makers is needed. These results are robust with respect to different shocks structures and to the timing of the game. Similar results are obtained when multiplicative uncertainty affects only fiscal policy (see Di Bartolomeo *et al.*, 2009). To obtain this it must be set that $\mu \sim (1, \sigma_\mu^2)$ and $\upsilon = 1$ in Equation (14).

Therefore, it can be concluded that multiplicative uncertainty about the effects of policy maneuvers does not permit the achievement of the targets in the equilibrium and symbiosis does not take place.

Another circumstance in which symbiosis does not necessarily occur is when fiscal and monetary authorities consider different variables in their loss functions. In this case it is not possible to have an agreement on the targets. This phenomenon can be evidenced by modifying one of the loss functions in the model. This can be shown following Lambertini (2004) and Lambertini *et al.* (2007), where the fiscal authorities have the following loss function:

$$L_{F,i} = \frac{1}{2}\left[(\pi - \pi_i^F)^2 + \beta_i^F (y_i - y_i^F)^2 + 2\phi_i f_i\right] \tag{15}$$

Therefore, in this specification national governments consider the fiscal stance (f_i) as an additional variable in their preferences. The central bank's loss function is still represented by (7) and the economy is modeled according to Equations (9) and (10). Under this structure, the first order condition for each fiscal authority becomes:

$$c(\pi - \pi_i^F) + \beta_i^F (y_i - y_i^F)(k_{ii} + b_i c) + \phi_i = 0 \tag{16}$$

While for the central bank is:

$$(\pi - \pi^M) + \sum_{i=1}^{n} \beta_i^M b_i (y_i - y_i^M) = 0 \tag{17}$$

It is easy to show that in this case the outcome $\pi = \pi^M = \pi_i^F = 0$ and $y_i = y_i^F = y_i^M = y^T$ does not satisfy the first order conditions and cannot be a solution of the game. Under this agreement about the targets, the first order conditions (16) and (17) are satisfied only if $\phi_i = 0$ for all i. Therefore, symbiosis occurs only if the fiscal authorities do not consider the fiscal variable in their loss functions, and then all the authorities in the monetary union share the same variables in their preferences.

The last assumption that can be removed is the one of common target values for the central bank and the governments. In the case of conflicting objectives between the monetary and fiscal authorities, Dixit and Lambertini (2000 and 2001) show that the equilibrium outcomes do not coincide with the bliss points and that they depend on the details of the institution, such as the commitment to a rule and the order of moves. The importance of the difference in the targets of the authorities is also analyzed by Demertzis *et al.* (2004) who stress that the conflict arising when authorities pursue their goals independently becomes stronger when preferences diverge (see also Hughes Hallet and Viegi, 2002). These results are easily obtained from the model formed by Equations (9) and (10) and by the loss functions (7) and (8) assuming that $\pi^M \neq \pi_i^F$ and $y^M \neq y_i^F$. Under these circumstances the equilibrium levels of inflation and output do not coincide with the targets of any authority[5]. In the case of divergent targets, symbiosis is not verified due to a non-cooperative race between the authorities that try to achieve discordant levels of output and inflation.

Symbiosis provides very appealing results for the institutional building of a monetary union, but it has to be noted that the three assumptions that have been relaxed in this section are very unlikely to happen all together in reality. First, the institutional architecture in the EMU separates the targets of the ECB and the objectives of national governments. The ECB is supposed to be concerned about inflation as its first objective, while fiscal discipline is a direct concern of single governments. A natural representation of this framework would not lead to a coincidence between the variables in the loss functions of the monetary and fiscal authorities. Second, economic policy uncertainty is difficult to measure, but there is a large consensus on

the fact that such circumstance can occur (see, for instance, Bloom, 2009; Bachmann *et al.*, 2013; Baker *et al.*, 2013). Moreover, in multi-country arrangements the effects of monetary policy are less predictable by the central bank, as the reaction to monetary shocks can differ between countries (see for instance Clausen, 2001; Calusen and Hayo, 2006). Third, economic and political heterogeneity across member countries also makes it very difficult to have fully concordant targets in practice.

Thus, the most relevant implication for these evidences is that symbiosis does not apply in reality and that the degree of commitment to a rule and discretion, the level of coordination, the order of moves and other characteristics of the interaction game, they all matter and require attention when the interaction between monetary and fiscal policies in a monetary union is analyzed. Nevertheless, symbiosis is still important because it serves as a benchmark for other solutions of the game since it is able to provide an equilibrium corresponding to the social optimum in which the bliss points of all agents are achieved.

4 Discretion Versus Commitment

There is a vast literature comparing the outcomes of monetary policy under commitment and discretion in a single country (see Walsh, 2010 for an overview of this literature). Kydland and Prescott (1977) and Barro and Gordon (1983a, b) show that surprise inflation, following the temptation to raise output above its natural level, generates an inflation bias. Then, the commitment of the central bank to a monetary policy rule is the natural solution as it eliminates the monetary authority's possibility to generate surprise inflation. Other solutions to this bias have been proposed, and they can be obtained under inflation targeting (Svensson, 1997 and 1999), with the provision of an optimal contract and incentives (Persson and Tabellini, 1993; Walsh, 1995), if the monetary authority is conservative (Rogoff, 1985b and Lohmann, 1992)[6]. One of the limitations of these contributions is that they do not take into account the interaction between fiscal and monetary policy. Among others, Dixit and Lambertini (2003b), Hughes Hallett *et al.* (2007) and (2009) fill this gap analyzing the outcomes under different combinations of discretion and commitment for the fiscal and monetary authorities in a single country framework. In this part of the literature it is shown that, taking into account the interaction in the policy mix, the outcomes can differ from the case where monetary policy is considered alone. This kind of analysis is easily adaptable to a monetary union framework. It can be assumed that the economy is still represented by Equations (7) and (8) and the authorities' loss functions are still represented by (5) and (6). In this specification it is not assumed that the monetary and fiscal authorities share the same targets; thus the assumption (9) is not kept. Moreover, the central bank is assumed to be at least as conservative as the fiscal authorities in all respects. Therefore:

$$\pi^M < \pi_i^F, \quad \beta_i^M \leq \frac{1}{n}\beta_i^F, \quad y_i^M < y_i^F \quad \forall i. \tag{18}$$

When all the authorities act discretionarily, under the assumption (18) the inflation

and output in the Nash equilibrium are the following:

$$\pi^* = \frac{\pi^M - \sum_{i=1}^n z_i \pi_i^F - \sum_{i=1}^n \beta_i^M b_i (y_i^F - y_i^M)}{1 - \sum_{i=1}^n z_i} < \frac{\pi^M - \sum_{i=1}^n z_i \pi^M}{1 - \sum_{i=1}^n z_i} = \pi^M < \pi_i^F \quad \forall i. \tag{19}$$

$$y_i^* = y_i^F - \frac{c}{\beta_i^F (c b_i + k_{ii})} (\pi - \pi_i^F) > y_i^F > y_i^M \quad \forall i. \tag{20}$$

where $z_i = \frac{\beta_i^M}{\beta_i^F} \frac{b_i}{b_i + k_{ii}/c} > 0$ under the assumption that c and all k_{ii} are positive. In other words, the outcome is more extreme than the ideal points of all policy makers, and it results in a too high output and a too low inflation. This result highlights how discordance in the targets does not allow symbiosis to occur. This happens because there is a non-cooperative race between the authorities. Fiscal authorities try to achieve output beyond the central bank's ideal, while the monetary authority aims at an inflation rate that is below the fiscal authorities' ideal. This conflicting situation results in an equilibrium where the level of inflation is too low and the level of output is too high. This equilibrium is not desirable because individuals will have a low level of leisure and excessive debt and higher interest rates will occur. It is worth noting that if $z_i > \frac{1}{n}$, the Nash equilibrium still provides a policy mix bias but with inverted deviations, as a too low output and a too high level of inflation occur. These results synthesize the general evidence in the literature that full discretion provides an equilibrium that is not consistent with the ideal levels and a policy mix bias occurs. Then, by plugging Equations (19) and (20) into (7) and (8) it can be shown that full discretion does not imply the social optimum as the bliss points of the players are not achieved ($L_M^{dis} > 0$ and $L_{F,i}^{dis} > 0, \forall i$). Therefore, under discretion the loss of all the authorities will be higher than the one obtained when symbiosis occurs ($L_M^{dis} > L_M^{sym} = 0$ and $L_{F,i}^{dis} > L_{F,i}^{sym} = 0, \forall i$). Furthermore, the more the priorities of the central bank and of the governments differ, the more their policies will be conflicting and the larger the policy mix bias (see also Demertzis *et al.*, 2004).

Having a conservative central bank suggests that a possible solution to the policy mix bias could be monetary policy leadership. In all the specifications analyzed so far, it has always been assumed that none of the authorities could act as a leader, Dixit and Lambertini (2001) study monetary leadership by assuming that the central bank chooses its monetary instrument before that fiscal policies are implemented. They show that under full discretion, monetary leadership can perform better than Nash equilibrium, but still does not provide the target values. In the case of discretionary monetary leadership the inflation rate results to be above the weighted average of the targets of all authorities by an amount that depends on the gap between the ideal outputs of the fiscal authorities and of the central bank[7]. The outcome is then non-optimal, but it is not as extreme as the one from the discretionary Nash equilibrium reported in Equations (19) and (20). Therefore, under monetary leadership the social optimum is not achieved, but the distance to the optimal welfare is lower. Then, it can be concluded that under monetary leadership the losses of all the authorities, $L_{F,i}^{cbl}$

and L_M^{cbl}, are lower than in the full discretion case, but do not achieve the bliss point ($L_M^{dis} > L_M^{cbl} > L_M^{sym} = 0$ and $L_{F,i}^{dis} > L_{F,i}^{cbl} > L_{F,i}^{sym} = 0, \forall i$).

Following the conclusions drawn by the literature on the inflationary bias emerging from discretionary monetary policies, the natural solution should be the commitment of the monetary authority to a rule. However, taking into account the interaction between fiscal and monetary policies allows for three different possible solutions. The first option is the one of full commitment, in which all the authorities commit to policy rules. Alternatively two partial commitment solutions are possible, one in which only the monetary authority commits to a rule and another where only the fiscal authorities are committed. In case of partial commitment in which only the monetary authority follows a policy rule, it is like the central bank announces its policy function before expectations are formed. Therefore, under rational expectations, choosing the level of π_0 can be regarded as choosing the level of π^e. Under this specification, Dixit and Lambertini (2001) show that this arrangement provides the same outcome as the discretionary monetary leadership. This implies that the commitment to a rule by the central bank improves the solution if compared to the case of full discretion, but does not outperform the case of discretionary monetary leadership ($L_M^{dis} > L_M^{cbl} = L_M^{cbcom} > L_M^{sym} = 0$ and $L_{F,i}^{dis} > L_{F,i}^{cbl} = L_{F,i}^{cbcom} > L_{F,i}^{sym} = 0, \forall i$). This is due to the fact that the beneficial effects of the monetary commitment are totally nullified by the discretionary fiscal policies in the union, as the latter act as a constraint for the monetary rule. Then, fiscal policy regulation can improve the performance of monetary commitment (or leadership), as it can shift the fiscal reaction functions in order to achieve more desirable combinations of inflation and output. Furthermore, according to Beetsma and Uhlig (1999) countries in a monetary union should also have incentives to adhere to a fiscal rule as it allows governments to internalize the long-run benefits of reducing the debt in terms of lower future inflation. This has been one of the arguments supporting the Stability and Growth Pact.

Therefore, the equilibrium that is potentially able to avoid the policy mix bias is the one of full commitment to policy rules in which also fiscal authorities adhere to a rule. Intuitively, when the authorities fix their targets according to policy rules, agree on them, and are concerned about the same variables, the outcome of full commitment provides the attainment of these targets. In such a case, the coalition consisting of all authorities is able to reproduce the situation in which symbiosis occurs and the social optimum (or bliss point) is achieved ($L_M^{com} = 0$ and $L_{F,i}^{com} = 0, \forall i$).

Provided that full commitment allows avoiding any policy mix bias, a relevant question concerns the optimal level of commitment. Hughes Hallett *et al.* (2007) agree with the conventional wisdom on the fact that full commitment is the most desirable arrangement, but they enrich this conclusion analyzing the required degree of commitment. They find that a certain degree of commitment is required in order to uniquely obtain the desired outcome for each authority. This minimum degree is a positive function of other authorities' degree of commitment, level of impatience of the authorities and the structure of the economy. Moreover, the optimal level of commitment is not necessarily the same for all the authorities. They show that undesirable scenarios can be avoided when monetary commitment is sufficiently stronger than fiscal commitment.

Although additive shocks have not been formally considered so far, it is worth noting that they play an important role in the commitment to a rule by policy makers. As highlighted by Beetsma and Uhlig (1999) and Dixit (2000), large and asymmetric shocks make it difficult to sustain a commitment rule. Therefore, the authors suggest that some degrees of flexibility are required in order to make the rules sustainable under severe asymmetric shocks. The degree of flexibility, however, is a very sensitive aspect especially for fiscal policy rules, as according to the degree of freedom fiscal policy can reduce both the central bank's commitment and conservativeness (see Dixit, 2001; Andersen, 2008).

The results highlighted in this section have some important institutional implications for the setting up of a monetary union. Provided that the assumptions that trigger symbiosis are very unlikely to occur in reality, the lack of rules and full discretionary policies should provide a policy mix bias in which the final outcome diverges from the initial targets. To avoid the results of this non-cooperative interaction, the formulation of policy rules is extremely needed. In the institutional framework of the EMU it is clearly stated, through a hierarchical mandate, that the ECB is intended to be a conservative monetary authority and fiscal rules, like the ones in the Stability and Growth Pact, have been considered as a necessary requirement. Nevertheless, the constraints on the conduct of fiscal policy and the convergence criteria have shown to be insufficient to implement a proper rule mechanism on the fiscal authorities' choices. According to the models presented in this section, this scenario can undermine the beneficial effects of the central bank's conservativeness and harm national economies in the long run. The implementation of mechanisms able to enforce a fiscal rule is then crucial in order to achieve the targets and to avoid divergent macroeconomic dynamics in a monetary union. Therefore, the reform of the Stability and Growth Pact should be pointing in this direction. Still, the flexibility of fiscal rules is also a necessary element in order to facilitate the management of asymmetric shocks and potential financial turbulence by national governments (see also De Grauwe and Ji, 2013b and 2013c; De Grauwe and Foresti, 2016).

5 Coordination and the Role of Spillovers

Under coordination joint decisions are taken by the policy makers. Coordination takes place when it is able to increase the satisfaction of each authority by eliminating the costs imposed by purely selfish decisions. The bargaining power of each authority determines how far its interests are met in the final equilibrium[8]. Before analyzing the main results in the literature on coordination in a monetary union, it is worth distinguishing between coordination and commitment. According to the definitions in the present study, commitment assumes that the authorities agree on a rule and respect it, while coordination means that the authorities set their policy jointly by taking into account each other's perspectives. Then, commitment implies that the authorities adhere to a rule, but their decisions can be taken separately; while under coordination the authorities set the policy mix together without adhering to a policy rule. Therefore, the main difference is that coordination does not necessarily affect

expectations as in case of commitment. Banerjee (2001) provides a clear distinction between these two cases.

In a monetary union there are two coordination problems. The first one concerns the coordination between the fiscal stance of the single governments (horizontal coordination problem). The second problem refers to the vertical coordination between one centralized monetary policy and many decentralized fiscal policies. Therefore there are two main coordination arrangements. One is the case of full coordination (both vertical and horizontal coordination occur simultaneously) and the other in which only horizontal coordination takes place.

Under full coordination, the central bank cooperates with the coordinated fiscal authorities that can be represented as a single one. This implies that all the authorities maximize a common loss function that is a weighted sum of their respective loss functions:

$$L_{M,F} = \eta L^F + (1 - \eta) L^M \tag{21}$$

Buti *et al.* (2001) show that, under different targets between fiscal and monetary authorities, the policy mix bias arises and its characterization depends on the bargaining power of the governments (η) and of the central bank ($1 - \eta$). They show that when the fiscal authorities pursue a positive output gap target, the coordination equilibrium provides a policy mix bias in which inflation and deficit distortions are experienced. According to the authors, the inflation bias is a positive function of governments' bargaining power and output target. Therefore, in the absence of shocks a conservative central bank has no incentive for full coordination. The same conclusion is drawn by van Aarle *et al.* (2002a) with a dynamic game. The authors show that full coordination induces a loss on the central bank, due to the coalition of governments. Then, the incentives for cooperation depend on the effects of shocks. In the presence of demand shocks the results are ambiguous and only in the presence of supply shocks the authors show that full coordination unambiguously provides welfare gains as in this case the two authorities react moving their instruments in opposite ways. Therefore, when the authorities have different policy objectives, full coordination suffers the same problems highlighted in the previous section. The only difference is that the bargaining power of the authorities determines the actual policy mix bias.

Referring to the importance of vertical coordination, it should be of no interest for the EMU as the ECB is not allowed to coordinate with the single countries' fiscal decisions. Although recent monetary policy arrangements have evidenced that under particular conditions the ECB may overcome this constraint, it does not imply that the ECB will coordinate with national governments in the policy mix.

In case of horizontal coordination only a sub-set of players (fiscal authorities) decide to act together. This immediately relates to a general conclusion of game theory models suggesting that when coordination takes place only between a sub-set of players, it could lead to such an adverse reaction of the outsiders that all players would gain by not coordinating (see Rogoff, 1985a). In the presence of exclusively

horizontal coordination, the outsider is the central bank. Therefore, in this scenario, the existing literature suggests that horizontal, without vertical, coordination may result to be counterproductive as it triggers an adverse reaction of the common central bank. However, some of the peculiar features of monetary unions make horizontal coordination beneficial under determined circumstances. They involve the symmetry of shocks and the spillovers between member countries. Beetsma *et al.* (2001), with a two country version of the model of Buti *et al.* (2001), show that horizontal coordination can be counterproductive in the presence of highly correlated shocks, because they increase the impact of time inconsistency in fiscal policies and they allow a stronger (counterproductive) reaction of the central bank. Then, they argue that since in a monetary union the presence of asymmetric shocks reduces the central bank's intervention, fiscal coordination increases its desirability the more asymmetric the shocks are (the same conclusion is drawn by van Aarle *et al.*, 2002b). Ferré (2005) also argues that horizontal coordination can be beneficial as it makes countries less sensitive to shocks leading to lower levels of public deficits.

The general result that horizontal coordination increases its performance when economies are structurally different is also confirmed by Hughes Hallett (2005) and (2008). The author investigates the importance of horizontal (although rule-based) coordination by assuming different sequential arrangements for the interaction game. He also explores the effects of giving the fiscal authorities a Stackelberg leadership, showing that the first-mover advantage allows governments to exploit the free-riding problem and shift the burden of stabilization on the central bank, resulting in a beneficial coordination. He concludes that fiscal leadership is the best outcome because it is able to minimize the conflict between policy makers without any need for a less independent central bank (see also Hughes Hallett and Ma, 1996). Other authors agree with the general conclusion that fiscal leadership can reduce the policy mix bias, but only under specific circumstances. Lambertini and Rovelli (2004) agree with this conclusion, but they assume that governments should adopt a loss function that takes into account also the objective of price stability. Debrun (2000) shows that fiscal distortions can be eliminated with fiscal leadership, as long as output does not enter as an exogenous term in the central bank's preferences. Kirsanova *et al.* (2005) show that fiscal leadership provides a better outcome, when compared with the Nash equilibrium, if the central bank is benevolent and fiscal authorities aim at an excessive level of output. These results are very important for the EMU as according to Beetsma and Bovenberg (1998) it may be characterized by fiscal leadership rather than monetary leadership. The authors argue that governments have a first mover advantage because, once the fiscal stance has been decided, they have no chance to react to subsequent monetary decisions and this rigidity replicates a commitment technology.

Also Kempf and von Thadden (2013) mainly rely on fiscal leadership in order to study the effects of horizontal coordination. Specifically, this study permits to analyze the effects of horizontal coordination by taking into account also the effects of both spillovers between private agents and fiscal spillovers. In order to formally consider private spillovers, the starting point of the model is now the payoff function of the

representative private agents as:

$$U_{j,i} = -\frac{1}{2}(a_{ji} - \pi)^2 - \frac{a_0}{2}u_i^2 - \frac{b_0}{2}\pi^2 - \frac{c_0}{2}\tau_i^2 \tag{22}$$

where a_{ji} is the nominal wage chosen by private agent j, then $(a_{ji} - \pi)$ is a measure of the individual real wage. The level of economic activity is now addressed by the aggregate unemployment in country i (u_i), while τ represents dead-weight losses associated with the use of the fiscal instrument. If τ is a lump-sum instrument the dead-weight losses disappear as it implies that $c_0 = 0$.

The loss function of fiscal authorities is obtained by the average of the payoff functions of the m private agents:

$$L_{F,i} = -\frac{1}{m}\sum_{j=1}^{m} U_{j,i} \tag{23}$$

While the loss function of the central bank is:

$$L_M = \sum_{i=1}^{n} L_{F,i} \tag{24}$$

The economy is represented by a single equation:

$$u_i = \overline{u} + \frac{1}{m}\sum_{j=1}^{m}(a_{ji} - \pi) - \tau_i - \frac{1}{n-1}\sum_{w=1,w\neq i}^{n} \overline{b_{iw}}\tau_w \tag{25}$$

Therefore, the realized unemployment rate depends on the union-wide real wage measure $\frac{1}{m}\sum_{j=1}^{m}(a_{ji} - \pi)$ and fiscal actions of all governments. Private spillovers are considered if $m > 1$, while fiscal spillovers are introduced when $\overline{b_{iw}} \neq 0$.

The solution of this model under fiscal leadership highlights that a monetary union can clearly benefit from horizontal coordination. To show this result, the solution of the model is retrieved assuming $c_0 > 0$, $m > 1$ and $\overline{b_{iw}} \neq 0$. Furthermore, without loss of generality the solution is obtained by also assuming that private spillovers have their maximum effect ($m \to \infty$). The solutions of the game under fiscal coordination (26) and non-coordination (27) are the following:

$$u^{co} = (1 - \Phi^{co})\overline{u}; \quad \pi^{co} = a^{co} = \frac{a_0}{b_0}u^{co}; \quad \tau^{co} = \frac{\Phi^{co}}{1 + \overline{b_{iw}}}\overline{u} \tag{26}$$

$$u^{nc} = (1 - \Phi^{nc})\overline{u}; \quad \pi^{nc} = a^{nc} = \frac{a_0}{b_0}u^{nc}; \quad \tau^{nc} = \frac{\Phi^{nc}}{1 + \overline{b_{iw}}}\overline{u} \tag{27}$$

where:

$$\Phi^{co} = \frac{a_0(1 + \overline{b_{iw}})^2(1 + \frac{a_0}{b_0})}{a_0(1 + \overline{b_{iw}})^2(1 + \frac{a_0}{b_0}) + c_0}; \quad \Phi^{nc} = \frac{a_0(1 + \overline{b_{iw}})(1 + \frac{a_0}{b_0}\frac{1+\overline{b_{iw}}}{n})}{a_0(1 + \overline{b_{iw}})(1 + \frac{a_0}{b_0}\frac{1+\overline{b_{iw}}}{n}) + c_0}; \tag{28}$$

Comparing Equations (26) and (27) it can be verified that the number of fiscal players (n) determines the difference between the two equilibria as it affects only

the outcomes under fiscal non-coordination. This result leads to the question how the gains from fiscal cooperation will be affected by changes in the number of fiscal players. To make this concern operational, the two equilibrium outcomes have to be compared in terms of welfare. The relevant welfare measure for this evaluation is captured by the evaluation of $U_{j,i}$. This is consistent with the welfare measure adopted so far as the level of $U_{j,i}$ directly determines also L_M and $L_{F,i}$ at the equilibrium outcomes. Then, by using Equations (22), (26), (27) and (28) it can be easily shown that $\frac{\delta(U_{j,i}^{co}-U_{j,i}^{nc})}{\delta n} > 0$. This means that the welfare gains from fiscal coordination (relative to non-coordination) increase as the number of countries n increases. Intuitively, with the costs associated with distortionary fiscal instruments occurring at the national level, there emerges under non-cooperation a free-rider problem vis á vis the monetary policy, and this problem gets worse as the number of countries becomes larger. This result is in line with the conclusion of Chari and Kehoe (1990) that cooperation will be beneficial for countries, even if their number becomes arbitrarily large, when they face distortions which will not be removed as the market power of countries goes to zero.

The fundamental aspects of the model that determine this result are the assumption of distortionary taxes (as opposed to lump-sum taxes) and the presence of private and fiscal spillovers. The beneficial effects of horizontal coordination disappear if (1) fiscal authorities use a non-distortionary instrument ($c_0 = 0$) or (2) there are no private and fiscal spillovers ($m = 1$ and $\overline{b_{iw}} = 0$). If one of these two conditions applies, the solution of the game with no coordination will be the same as under horizontal coordination. Solving for instance the model assuming that $c_0 = 0$, Equation (28) implies that $\Phi^{co} = \Phi^{nc} = 1$. Then, by using Equations (26) and (27), the solution of the model becomes:

$$u^{nc} = u^{co} = 0; \quad \pi^{nc} = \pi^{co} = 0; \quad a^{nc} = a^{co} = 0; \quad \tau^{nc} = \tau^{co} = \frac{\overline{u}}{1 + \overline{b_{iw}}} \tag{29}$$

Given Equations (22), (23), (24) and (29) it is clear that this solution reaches the bliss point of all the agents and $L_M = L_{i,F} = U_{j,i} = 0$ irrespective of fiscal coordination. Imposing that $m = 1$ and $\overline{b_{iw}} = 0$ provides similar results, in the sense that there is no difference between the solution under horizontal coordination and no coordination. Nevertheless, it can be shown that under this circumstance the bliss point is not reached due to the distortionary instrument adopted by fiscal authorities (see Kempf and von Thadden, 2013). However, as in the case of symbiosis, these two assumptions seem to be too restrictive and it can be concluded that a monetary union characterized by fiscal leadership should enhance horizontal coordination as long as governments use distortionary fiscal instruments and there are fiscal and private spillovers.

Contrary to vertical coordination, horizontal coordination is in the agenda of the EMU as the article 103 of the Maastricht Treaty stresses that member countries should coordinate their economic policies within the Council of Ministers. However, it seems that in practice international policy coordination has not taken the form of joint decisions, but rather of a mere exchange of information or, at best, informal agreements on a set of mutually consistent external objectives. This can be explained

by the fact that coordination is costly. In order to have a secured coordination, many institutions are required and they are all costly (a stable institutional framework, control instruments, formal meetings etc.). These costs are rarely considered in theoretical models, but it is sometimes argued that they can easily more than compensate the benefits deriving form coordination (see Beetsma *et al.*, 2001). Moreover, the main results in the literature highlight a serious risk of counterproductive fiscal coordination. This is especially the case when shocks are highly correlated between countries. Then, from the perspective of the OCA theory (see Mundell, 1961; McKinnon, 1963; Kenen, 1969), fiscal coordination is most likely to be undesirable when a set of countries form an optimum currency area. Nevertheless, given the severe asymmetric shocks that have occurred across the EMU, theoretical models suggest that strengthening horizontal coordination is a good way to deal with this problem and to improve the future functioning of the union. In this sense, the setting up of a fiscal union is intended to increase fiscal coordination (see Schelkle, 2012). Moreover, the ongoing process of enlargement of the EMU will increase the number of fiscal players and, as shown in this section, this should increase the potential beneficial effects of horizontal coordination.

6 National Versus Union-wide Average Data and the Reaction to Shocks

When a common central bank takes its decisions in a monetary union, it is very important to assess which type of data have to be taken into account. The most relevant question is if the monetary authority should adopt union-wide data or if national characteristics should be considered for its policy making. The relevance of this question increases dramatically in the presence of economic asymmetries between member countries as in this case the idea that "one size monetary policy fits all" does not necessary satisfy the needs of all member countries. In the case of the EMU, significant differences between member states have been detected. Asymmetries have been evidenced in inflation, growth and debt (see Angeloni *et al.*, 2005). There is also evidence of the existence of asymmetries that can generate multiple equilibria (see De Grauwe, 2012; De Grauwe and Ji, 2013a, Borgy *et al.*, 2014) and divergent macroeconomic dynamics (see Hancké, 2013 and Foresti, 2015). The question is whether the central bank should take into account these heterogeneities or not.

The answer coming from the institutional framework of the EMU is negative as the ECB wants to represent itself as a supranational institution, rather than a board of several national authorities, in order to minimize the political sensitivities of the weights in the voting rules (see Alesina and Grilli; 1992 and 1993). Therefore, in its official pronouncements the ECB has manifested that its monetary policy is conducted on the basis of union-wide average data. Nevertheless, there is no full agreement in the literature on this approach. Farhi and Werning (2014) and Benigno (2004) argue that monetary policy can be chosen at the union level so that monetary conditions are adapted to the average country. Galí and Monacelli (2008) and Beetsma and Jensen (2005) agree with this result, but they show that this is optimal only if fiscal

policies pose no inflationary pressures on the union as a whole and stabilize relative inflation. Furthermore, De Grauwe (2000) and De Grauwe and Sénégas (2006) show that by using national information the central bank can improve the efficiency of its policy setting when there are asymmetries in the monetary policy transmission mechanisms. De Grauwe and Sénégas (2004) follow the same reasoning and show how the enlargement of the EMU requires that the ECB takes into account national data as the degree of asymmetry should increase together with the entrance of new member countries. At the same time, when monetary policy cannot make distinctions between member countries, the increase in the asymmetries between supply shocks makes the monetary authority less active (see also Lane, 1996; Gros and Hefeker, 2002; Foresti and Marani, 2013).

In these studies monetary policy is analyzed without directly investigating its interaction with an optimizing fiscal authority. When the interaction between a centralized monetary authority and many decentralized fiscal authorities is studied this issue becomes even more relevant since, as already evidenced in the previous sections, each government considers its national data in the fiscal policy setting. When the central bank conducts its monetary policy on the basis of union-wide average data, the results and the effectiveness of the policy mix on the macroeconomic aggregates are necessarily affected by this asymmetry. This issue can be tackled following Bofinger and Mayer (2007), where the loss function of the central bank is the following:

$$L_M = \frac{1}{2}(\pi - \pi^M)^2 + \frac{1}{2}\beta^M y^2 \tag{30}$$

For the sake of simplicity the output gap target is set to zero. Equation (30) implies that the central bank takes its decisions on the basis of average macroeconomic data in the union. The average output gap ($y = \frac{1}{n}\sum_{i=1}^{n} y_i$) is represented by the following demand equation:

$$y = \overline{y} - \lambda\rho + kf + \varepsilon_1 \tag{31}$$

Where $\rho = r - \pi$ represents the real interest rate and f is the union-wide average fiscal policy variable ($f = \frac{1}{n}\sum_{i=1}^{n} f_i$). Assuming that monetary policy is credible ($\pi^e = \pi^M$), inflation can be modeled by the following supply equation:

$$\pi = \pi^M + \alpha y + \varepsilon_2 \tag{32}$$

As shown in Equations (31) and (32), from now on i.i.d. demand (ε_1) and supply (ε_2) shocks are formally considered. In this model the central bank's monetary instrument is the nominal interest rate (r).Then, the central bank minimizes (30) subject to (31) and (32), and its best response function is the following:

$$r = \frac{\overline{y}}{\lambda} + \pi^M + \frac{\lambda\beta^M + \alpha}{\lambda(\alpha^2 + \beta^M)}\varepsilon_2 + \frac{k}{\lambda}f + \frac{1}{\lambda}\varepsilon_1 \tag{33}$$

Equation (33) represents how the central bank fixes the nominal interest rate as a function of the average fiscal stance in the union.

Each government sets its fiscal policy on the basis of its national data. Therefore, the fiscal authorities' loss function can be written as follows:

$$L_{F,i} = \frac{1}{2}y_i^2 + \frac{1}{2}\gamma f_i^2 \tag{34}$$

Where γ represents the weight that the primary deficit (f_i) have with respect to the output-gap in the government's preferences. From Equation (34) it is clear that each government has a target of 0 for the two variables. Each member country considers the following national demand equation:

$$y_i = \overline{y} - \lambda\rho + kf_i + \varepsilon_{1,i} \tag{35}$$

Equation (35) assumes the absence of fiscal policies spillover effects and the symmetry of the demand parameters across member countries. Solving the governments' optimization problem yields the following best response function:

$$f_i = -\frac{\overline{y}k}{k^2+\gamma} + \frac{\lambda k}{k^2+\gamma}(r-\pi) - \frac{k}{(k^2+\gamma)}\varepsilon_{i,1} \tag{36}$$

If monetary policy gets more restrictive, the government will switch to a more expansionary stance. The higher the weight on stabilizing its instrument (γ), the lower will be the strategic interaction with the central bank. Given its objective function, fiscal policy reacts only to demand shocks. For instance, following a positive demand shock, fiscal policy will become more restrictive. There is not a direct reaction of the fiscal authorities to the union-wide supply shocks as they have an impact on the fiscal policy only via the central bank's reaction[9]. The best response functions (33) and (36) highlight the main feature of the interaction between the monetary and the fiscal authorities. The latter conduct their policies on the basis of national shocks, while the former responds to their union-wide averages.

In the Nash equilibrium the output gap in each country and the common interest rate are:

$$y_i^* = -\frac{\alpha}{\alpha^2+\beta^M}\varepsilon_2 + \frac{\gamma}{k^2+\gamma}(\varepsilon_{i,1} - \varepsilon_1) \tag{37}$$

$$r^* = \pi^M + \frac{\overline{y}}{\lambda} + \frac{1}{\lambda}\varepsilon_1 + \frac{\lambda\beta^M + \alpha(1+\frac{k^2}{\gamma})}{\lambda(\alpha^2+\beta^M)}\varepsilon_2 \tag{38}$$

When fiscal authorities are concerned only about output ($\gamma = 0$), they can completely stabilize idiosyncratic demand shocks. If fiscal policy exhibits an increasing passiveness (increasing γ), cycles are more likely to become non-synchronized. To illustrate this point, the average demand shock is written as $\varepsilon_1 = \psi\varepsilon_{i,1} + (1-\psi)\varepsilon_{-i,1}$ (where ψ

is the GDP share of country i in the union) and it is assumed that a demand shock hits only country i ($\varepsilon_1 = \psi\varepsilon_{i,1}$). Then, the level of output gap in country i and in the rest of the union can be calculated by using Equation (37):

$$y_i^* = \frac{\gamma}{k^2+\gamma}(1-\psi)\varepsilon_{i,1} \qquad \text{and} \qquad y_{-i}^* = -\frac{\gamma}{k^2+\gamma}\psi\varepsilon_{i,1} \tag{39}$$

Then, the member countries' equilibrium output is affected asymmetrically by the shock. Furthermore, the strength of this feedback depends on the GDP share of the country hit by the demand shock. Asymmetric shocks are a major problem for small countries participating in the union. In the limit, when the GDP share of an individual member country (ψ) is almost zero, the shock will be passed through completely if fiscal policy remains passive ($\gamma \to \infty$). Then, it can be concluded that fiscal policy is extremely needed in small countries in order to smooth the impact of shocks. Therefore, this model confirms the predicament of the OCA theory that monetary unions function well when demand shocks are highly correlated and fiscal policy actively stabilizes the business cycles. Equation (38) also shows that when country i is the only hit by a demand shock, all other member countries are forced to share the burden of a higher interest rate. The analysis of monetary policy in asymmetric currency unions changes if the assumption of a common inflation rate is removed. Benigno (2004), focusing on monetary policy, suggests that the central bank should target the average level of inflation only if countries show the same degree of nominal rigidities. If rigidities are not symmetric across member countries, the central bank should target inflation by assigning a higher weight to the inflation in the countries with high nominal rigidities. Benigno and Lopez-Salido (2006) generalize this concept and argue that under these circumstances monitoring output gap can provide the right information on the final target. Concerning the role for fiscal policy, Bofinger and Mayer (2007) argue that inflation differentials imply diverging real interest rates, calling for more active fiscal policies in order to smooth out the business cycle. This is particularly true for small countries, whose idiosyncratic situations are likely to be neglected by the central bank targeting average data. According to the authors this supports the idea that, concerning the EMU, the 3% deficit criterion should be suspended when a country is hit by an asymmetric shock. At the same time, such fiscal interventions are supposed to affect real interest rate volatility and generate negative spillovers. These elements support the creation of the Stability and Growth Pact in order to minimize such spillovers but they also reinforce the evidence for the need of flexibility in fiscal rules.

7 Public Debt Management and Solvency Risk

Another aspect in which the effects of the policy mix are severely affected by the asymmetries between union-wide and national data is the management of public debt. In a broad sense, management of national debts and deficits in a monetary union is a very sensitive topic as fiscal authorities are supposed to stabilize public debt on their own. Moreover, the share of public debt stabilization left to single countries increases

when national fiscal authorities do not coordinate (see van Aarle *et al.*, 1997). In Foresti (2015) the framework of Bofinger and Mayer (2007) is modified in order to analyze how the interaction between a union-wide data conducted monetary policy and national data based fiscal policies can affect the management of public debt in a monetary union. To this aim, the central bank optimization problem can still be represented by Equations (30), (31) and (32). The fiscal authorities still consider the national demand Equation (35) but their loss function is now:

$$L_{F,i} = \frac{1}{2}y_i^2 + \frac{1}{2}\theta d_i^2 \tag{40}$$

In this loss function it is assumed that the governments are directly concerned about the level of public debt d_i. Moreover, each fiscal authority knows that the outstanding level of debt is generated according to the following relation:

$$d_i = (1+\rho)\overline{d_i} + f_i \tag{41}$$

The outstanding level of debt in country i is generated by the fiscal stance, by the debt accumulated before the fiscal maneuver ($\overline{d_i}$), and by the debt service real cost ($\rho\overline{d_i}$)[10]. Minimizing (40) subject to (35) and (41), each government obtains its best response function:

$$f_i = -\frac{\overline{y}k}{k^2+\theta} + \frac{\lambda k}{k^2+\theta}(r-\pi) - \frac{k}{k^2+\theta}\varepsilon_{1,i} - \frac{\theta}{k^2+\theta}(1+r-\pi)\overline{d_i} \tag{42}$$

The most interesting aspect of this best response function is obtained by comparing it with Equation (36), as in Equation (42) $\frac{\delta f_i}{\delta r} = \frac{\lambda k - \theta\overline{d_i}}{k^2+\theta}$. According to Equation (36), when the central bank performs restrictive monetary policies, the governments implement expansionary fiscal policies because in that framework they consider only the restrictive effects of the monetary maneuver on the output gap. However, when the governments are debt-concerned, they also consider the fact that the restrictive monetary policy increases their level of debt. Hence, the fiscal authorities face a trade-off between output gap stabilization and debt stabilization. The higher the accumulated level of debt ($\overline{d_i}$) and the higher the weight for the debt stabilization in the governments' preferences (θ), the more the governments' fiscal stance reacts negatively to an increase in the interest rate by the monetary authority. On the contrary, the higher the impact of the fiscal stance on the output gap (k) and the reaction of the output gap to monetary policy (λ), the more the fiscal authorities' fiscal stance reacts positively to a central bank's restrictive maneuver.

The most relevant part of the solution of the model refers to the optimal level of debt in country i:

$$d_i^* = \frac{\lambda k}{(k^2+\theta)(\lambda+k\overline{d})}(\varepsilon_1 - \varepsilon_{1,i}) + \frac{k^2}{(k^2+\theta)(\lambda+k\overline{d})}(\overline{d_i}\varepsilon_1 - \overline{d}\varepsilon_{1,i}) + \\ + \frac{(\overline{d_i}-\overline{d})(\overline{y}+\lambda)k^2}{(k^2+\theta)(\lambda+k\overline{d})} + \frac{(k^2\overline{d_i}+\lambda k)(k^2+\theta)\alpha}{(k^2+\theta)(\alpha^2+\beta^M)(\lambda+k\overline{d})\theta}\varepsilon_2 \qquad (43)$$

Equation (43) shows that when there are no supply shocks ($\varepsilon_2 = 0$), demand shocks are perfectly symmetric ($\varepsilon_1 = \varepsilon_{1,i}$) and the level of existing debt in country i is equal to the union-wide average ($\overline{d} = \overline{d_i}$), the fiscal authority in country i is able to reach its zero-debt target. According to the OCA theory, the situation in which there are no supply shocks and the demand shocks are perfectly symmetric should be easily manageable by the policy makers and highly desirable. Nevertheless, in order to fully exploit the benefits of this situation, it is necessary that the accumulated national debts converge. If country i has a level of accumulated debt that is higher than its union-wide average, the equilibrium level of debt in this country will be above the target. Moreover, the stronger the demand shocks, the more the equilibrium debt in country i moves away from the target.

Given the authorities' reaction functions (42) and (33), the origin of this mechanism can be explained by the fact that monetary policy is set on the basis of average data, then the central bank takes its decisions on the basis of the average accumulated level of debt. On the contrary, national fiscal policies rely on national data and the fiscal authorities conduct their policies on the basis of the national accumulated level of debt. Therefore, when the same demand shock occurs all over the union, the monetary maneuver will not be consistent with the needs of a country with an outstanding level of debt that is above the union average as the central bank reacts considering a lower level of outstanding debt. As a result, the equilibrium level of debt in this country increases. Gatti and van Wijnbergen (2002) also show that under symmetric shocks a fiscal coordination failure is triggered when the central bank targets union-wide average data on fiscal policies. The solution they propose is that the central bank should implement a reward to governments' fiscal restraints. Also Chari and Kehoe (2007 and 2008) support the creation of debt constraints but they show that under asymmetric structural distortions between member countries, uniform debt ceilings must be complemented by country-specific debt targets. The importance of debt ceilings is also supported by Beetsma and Bovenberg (1999) and (2005), as they show that national debts can be wastefully accumulated when there is a conflict between monetary and fiscal authorities.

Another relevant result highlighted by Equation (43) is that member countries with a debt above the average in the union will not be able to converge to the target level of debt. On the contrary, divergent equilibria can be experienced and this can endanger the existence of the monetary union due to the increasing solvency risk for the highly indebted member countries. When there is a constant increasing path of public debt in some member countries that increases their solvency risk, three main scenarios are possible: (1) national governments take care of their public debt, for instance, by increasing taxation and reducing expenditure; (2) the central

bank monetizes the public debt; (3) default due to insolvency. Cooper *et al.* (2010) show that monetization and increase in taxation can arise as possible equilibrium configurations. The authors show that the element that determines which solution characterizes the equilibrium depends on the debt distribution in the union. The more even is this distribution, the more likely is that the central bank will prefer to avoid a costly default and monetizes the debt of one member country offering a bail out. Then, this implies the presence of debt spillovers between member countries as fiscal policies in some member countries may affect the union wide inflation via monetary policy. Cooper *et al.* (2014) show that there is no possibility of insulating the monetary authority from such debt spillovers.

The last important insight from Equation (43) is that differences among member countries in their level of public debt should be a crucial indicator, more than the level of debt itself. The more the debt in one country is above the union average, the more difficult will be its stabilization and the higher the risk of insolvency. This result contrasts with conventional wisdom that all countries should just prefer to join a union with low debt members. Also Aguiar *et al.* (2015) show that, high-debt countries may be less vulnerable to roll-over crises when belonging to a union formed by a mix of high- and low-debt members than to one where all other members have low-debt.

The results presented in this section provide relevant insights for the debate on the institutional and economic policy arrangements in a monetary union. As long as asymmetries between member countries will characterize the EMU, it is clear that the problems highlighted in this section are extremely important and that mechanisms able to take into account different national needs in the policy mix (both in fiscal and monetary policies) should be enhanced. The ECB is a supranational autonomous institution, therefore it seems very difficult to make the central bank capable of considering national differences. Nevertheless, it can be argued that the implementation of unconventional monetary policies should be able to partially solve this problem. The quantitative easing maneuvers implemented by the ECB seemed to be a step towards this direction. Nevertheless, as long as this buying program implies that governments' bonds are purchased roughly in proportion to the capital that each member central bank has contributed to the ECB, it will not allow the common central bank to differentiate between members' needs. Another point raised by the models presented in this section suggests that the rationale for the debt convergence criteria should be reconsidered, as a very important aspect is the gap between the average accumulated level of debt and its level in single countries. Once countries with a debt above the union average enter a monetary union, convergence to targets may never occur. On the contrary, under precise circumstances the debt gap can increase, endangering the existence of the whole union. For all these reasons theoretical models suggest that common debt ceilings should be complemented with country specific targets (see for instance Chari and Kehoe, 2007, 2008) or replaced by rules responding to a measure of real activity (Ferrero, 2009).

8 Conclusion

In this paper, the theoretical literature studying the interaction between monetary and fiscal policies in a monetary union has been surveyed and, on the basis of its most relevant results, some suggestions for the improvement of the functioning of the EMU have been provided.

Despite the fact that the concept of symbiosis offers very appealing theoretical elements for the institutional architecture of a monetary union, it has been shown that it holds only under some assumptions: (1) the authorities share the same variables in their loss functions, (2) they agree on the target levels and that (3) the authorities do not face model uncertainty. It has been argued that such assumptions are unlikely to be verified altogether in reality. For instance, in the EMU architecture the targets of the ECB and the objectives of national governments are separated. Moreover, economic and political heterogeneity between member countries makes it also very difficult to have fully concordant targets in practice and certain degree of policy uncertainty is always present.

The fact that symbiosis seems to remain a mere theoretical fact implies that the degree of commitment to a rule and discretion, the level of coordination, the order of moves and other characteristics of the interaction between fiscal and monetary policies are all relevant elements able to affect the policy mix outcome in a monetary union.

Concerning the role of commitment, it has been demonstrated that the lack of rules and full discretionary policies provide a policy mix bias in which the final outcome diverges from the initial targets. Therefore, to avoid the results of this non-cooperative interaction, policy rules seem to be extremely needed. Nevertheless, the presence of shocks suggests that such rules should be designed in order to allow for some flexibility in fiscal policy. This result should be a warning for the EMU, where the necessary fiscal reforms have gone in the direction of more rigid rules.

In relation to policy cooperation, a relevant distinction has been made between vertical and horizontal coordination. The former should be of no interest for the central bank due to the result that it may harm monetary conservativism. Despite the risk of counterproductive fiscal coordination in the the case of highly correlated shocks between countries, theoretical models suggest that strengthening horizontal coordination is a good way to deal with severe asymmetric shocks and to improve the functioning of a monetary union. It has also been shown that the relevance of this argument increases together with the number of member countries. These results support the setting up of the fiscal union in the EMU as it is will increase fiscal coordination.

As a last step, also the potential role of national data in the setting up of the policy mix has been analyzed. As long as asymmetries between member countries characterize a monetary union, mechanisms able to take into account different national needs in the policy mix (both in fiscal and monetary policies) should be enhanced. It has been shown that the type of data considered affects the management of debt in the member countries. Once countries with a debt above the union average enter a monetary union, convergence to targets may never occur. On the contrary, when the central

bank takes its decisions on the basis of union-wide average data, the debt gap can increase endangering the existence of the whole union. By introducing common debt ceilings complemented with country specific targets, the impact of this phenomenon should be reduced.

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Notes

[1]For the monetary and fiscal authorities these are normally assumed to be their policy instruments.

[2]In the literature it is normally assumed a common level of inflation for the whole union. This assumption is motivated by the fact that member countries are subject to common monetary conditions as monetary policy is centrally determined. Nevertheless, there is evidence of inflation differentials in monetary unions (see Honohan and Lane, 2003). However, when countries enter a monetary union with inflation differentials, the convergence to a common price level determines a differential in inflation rates (De Grauwe, 2000)

[3]Without loss of generality the parameter c has been assumed to be constant across member countries. It is common practice in the literature to assume that $k_{ii} > 0$, $c > 0$, and $b_i > 0$.

[4]Although in this study symbiosis has been obtained in a monetary union, it can be shown that the same results hold in a single country framework (see Lambertini, 2006). Thus, for the sake of simplicity, the authors consider the case of one country, but their results can be easily extended to a monetary union.

[5]The formal derivation of this equilibrium is reported in the next section when the case of full discretion is analyzed.

[6]The results of this literature can be considered as one of the motivations behind the strong orientation towards inflation and conservativism of the ECB. This is oriented towards building commitment and credibility in central banking as they are considered to be welfare improving.

[7]Following the same reasoning, it can be shown that in the discretionary fiscal leadership equilibrium, output is above the weighted average of the targets by an amount that depends on the difference in the target inflation between monetary and fiscal authorities.

[8]Bargaining power is normally measured with the inverse of the authority's loss if the bargain breaks down.

[9]Uhlig (2003) shows that under fiscal leadership the governments' directly react also to the union supply shocks.

[10]Possible seigniorage revenues are not taken into account because they are supposed to play an almost negligible role in a monetary union.

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