Macroeconomic stabilisation policies in the EMU: Spillovers, asymmetries, and institutions*

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Abstract

This paper studies the spillover sizes and signs and the institutional design of the co-ordination of macroeconomic stabilisation policies within the European Economic and Monetary Union (EMU). Moreover, in a dynamic setup, the consequences of this institutional design on macroeconomic outcomes and policies are analysed. We distinguish two types of co-ordination: *ex-ante* - related to the institutional framework; and *ex-post* concerning the actual policy decisions. The first type is modeled as the result of an endogenous coalition formation process that leads to the formation of policymakers' coalitions. *Ex-post* co-ordination implies then the implementation by each coalition of its internally co-ordinated macroeconomic stabilisation policies in a non-co-operative dynamic game with the other coalitions, and subject to the constraints of the internal dynamics of the EMU economy.

The paper shows that the institutional setting of macroeconomic policy co-ordination is of crucial importance in reaching the Pareto-optimal equilibrium of the game, especially when the number and the magnitude of asymmetries increase. The specific recommendations depend on the particular characteristics of the shocks and the economic structure. In the case of a common shock, fiscal co-ordination is counterproductive but full policy co-ordination is desirable. When asymmetric shocks are considered, fiscal co-ordination improves the performance but full policy co-ordination doesn't produce further gains in policymakers' welfare. In general, structural asymmetries reduce the gains from co-operation so that in many cases co-operation cannot be supported without introduction of exogenous factors, e.g. a transfer system.

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1 Introduction

On January 1st 2002, the euro notes and coins have been introduced in 12 EU countries. These are the most tangible signs of the new economic and political regime established by the Economic and

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Monetary Union (EMU) whose formal operation started on January 1st 1999, after the prolonged preparation period laid out in the Maastricht Treaty of 1991.

The main institutional change in EMU is clearly the constitution of a common central bank (European Central Bank - ECB). Moreover, fiscal policies are now regulated according to the Broad Economic Policy Guidelines (BEPGs) established by the European Commission (EC) in 2000 and the decisions taken within the *ECOFIN Council* of (Economics and Finance) Ministers (for the whole EU) and the *Eurogroup* (for the EMU)[1]. For example, the fiscal policy of the EU Member States is monitored within the framework of the BEPGs by the EC with recommendations, warnings, and judgements. An example is the *ECOFIN Council* recommendation to Ireland on the 12th of February 2001, addressing the inconsistency between the Irish budget for 2001 and the BEPGs. Other cases are the recommendations with early warnings by the EC for Germany and Portugal on the 11th of February 2002 and more recently - on the 21st of January 2003 - for France. However, the institutions and the procedures for economic policy co-ordination are far from being completely established, and, therefore, several matters are still under discussion. Having in mind this context, this paper studies the institutional design of the co-ordination of macroeconomic stabilisation policies within the EMU and its consequences on macroeconomic outcomes and policies.

Fiscal policy co-ordination in a monetary union is directly linked to the sizes and signs of the spillovers and externalities resulting from national fiscal policies. The sign and size of fiscal spillovers are crucial since they ultimately determine whether co-ordination should lead to a more expansionary or a more restrictive fiscal stance in the Member States. For example, if governments perceive negative spillovers in a static game, they would interpret non-co-operative ("beggar-thy-neighbour") policy in response to bad economic shocks as too expansionary and would agree on a more restrictive stance in all countries. By contrast, if governments perceive positive spillovers, co-ordination should eliminate free-riding behaviour of individual countries and promote more expansionary policy in response to bad economic shocks. In a dynamic setting the situation is more complicated as the size, persistence and signs of the spillovers may change markedly over time.

The EMU is clearly a highly integrated economic area with a large number of interactions between the participating countries. However, empirical estimations of spillovers in such a context are not (yet) available[2] and the theoretical literature does not provide a clear-cut answer about the sign of fiscal policy spillovers. The traditional argument in favour of international policy co-ordination is based on direct positive demand spillovers. By contrast, more recent, micro-founded models of the EMU tend to conclude in favour of negative fiscal spillovers by emphasizing the adverse terms-of-trade effects of balanced-budget foreign fiscal expansion on the domestic economy. Furthermore, the possibility of accumulating public debts might add other sources of negative spillovers through the common nominal interest rate.

In the EMU a central role is played by the co-ordination of the fiscal policies among the national governments[3] and, moreover, their co-ordination with the monetary policy of the ECB. In general, two kinds of co-ordination can be distinguished (Beetsma et al. (2001)): institutional (or *ex-ante*) co-ordination, and policy (or *ex-post*) co-ordination.

Ex-ante co-ordination is related to the institutional framework, the co-ordination procedures, and the design of policy rules, whereas *ex-post* co-ordination takes place from the current state of affairs and concerns the actual policy decisions. More in particular, *ex-ante* co-ordination operates through formal binding agreements recognised by the policymakers as international obligations (e.g.

[1] The *Eurogroup*, however, is not officially institutionalised, but is an informal meeting of the Ministers of Finance of the EMU Member States.

[2] A very preliminary attempt to estimate cross-country spillovers within EMU is provided by Monteforte and Siviero (2003). Moreover, Monfort *et al.* (2002) try to empirically disentangle common shocks and spillover effects in a multi-country setting.

[3] Inflation bias, which may arise in the setting of fiscal policy, is likely to be stronger in a multi-country monetary union with nationally-set fiscal policies than in the case of EMU-wide set fiscal policies. It is important, therefore, to design institutions for commitment and co-ordination of fiscal policies in order to mitigate such biases (CESifo (2002, Chapter 3)).

the *Maastricht Treaty* and the *Stability and Growth Pact* (SGP)). By contrast, *ex-post* co-ordination has an informal character, and refers to discretionary and *ad hoc* informal agreements stipulated among the countries.[4] The two kinds of co-ordination are strictly interconnected. In fact, e.g., the SGP might strongly reduce the room for discretionary co-ordination of the national fiscal policies. Similarly, discretionary agreements among the countries might depend on the design of the European institutions concerning fiscal co-operation as, e.g., the *ECOFIN Council*.

We consider, in a dynamic modelling framework, that foreign fiscal policy can affect the domestic economy through the terms-of-trade, the real interest rate, and external demand spillovers. Different signs of the spillovers can arise according to different parameterisations of the model. In the context of co-ordination of macroeconomic stabilisation policies the following topics will be discussed:

1. The *assignment issue* that consists in deciding which institution is responsible for which policy target and at which scope. And, in addition to it, which policy tool is assigned to which policy institution. It is of particular interest to study the effects of different governments' priorities in a monetary union where the monetary policy is fully delegated to a unique central bank, which is mainly associated with price stabilisation (Art. 105 *Treaty of European Community*, TEC).

2. The *institutional framework* where both the assignment and the co-ordination are solved (*ex-ante* co-ordination). In particular, the concept of *ex-ante* co-ordination is related to the functions that should be associated with the *Eurogroup* and the *ECOFIN Council*. In fact, different degrees of enforcement associated with the *ECOFIN Council* recommendations and judgements might have a crucial effect on macroeconomic policy co-ordination, or on the failure in implementing it.

3. The *ex-post* co-ordination issue among the fiscal authorities and between them and the ECB. This issue in the EMU adds a new feature to the traditional issues related to the public good nature of price stability and the macroeconomic externalities due to the national fiscal policies. In fact, in the EMU the co-ordination problem is very much focused on enforcing budgetary discipline (Art. 104 TEC and the SGP).

Regarding the *assignment issue* we will consider different priorities for output gap and inflation for the fiscal and monetary authorities. The governments are mainly concerned with output gap stabilisation whereas the ECB's primary target (according to Art. 105 TEC) is stability of prices in the Euro-area. In addition, we introduce deficit stabilisation as an explicit objective of the individual governments. By doing this we include the fiscal stringency requirements of the SGP as an element in the decision making problem of the fiscal authorities. Interest rate smoothing is included in the objectives of the ECB. In the context of the EMU it is interesting to analyse how such externally imposed institutional restrictions on policy instruments affect the design of optimal policies and aspects of policy co-operation.

The institutional framework (*ex-ante* co-ordination) is introduced by considering different rules, procedures and information shared among policymakers, which taken together characterise the negotiations among policymakers in determining co-operation agreements. Different institutional settings may have different effects on the implementation of co-operative policies. In fact, some institutional setups may not be able to promote co-operation, even when co-operative policies increase the welfare of policymakers because of free-riding behaviour.

Ex-post co-ordination will be studied in a dynamic framework to emphasize the dynamic character of both direct and indirect spillovers arising from the behaviour of national fiscal policies in an integrated area as the EMU. The direct spillovers from fiscal policies result from the effect of domestic

[4] As it is pointed out by Beetsma *et al.* (2001), we can think of the *Eurogroup*, in which the Finance Ministers of the EMU area discuss fiscal policies in an informal way, as a forum of *ex-post* co-ordination. Furthermore, also the *ECOFIN Council*, notwithstanding its more formal nature, is characterised by largely discretionary decisions and can, therefore, be interpreted as a formal institution where not only formal but also informal agreements take place.

output on foreign output via the export channel. The indirect spillovers result from the effects of fiscal policies on the dynamics of inflation rates, intra-EMU competitiveness, and interest rates.

Our paper extends the literature in three respects.

(a) From the methodological point of view, this paper extends Di Bartolomeo *et al.* (2002b) by considering a more general shock structure - based on inflation instead of competitiveness - in the model dynamics. Moreover, more general inflation dynamics are considered: the effects of foreign inflation rates are included, as suggested by the recent open-economies' literature.[5]

(b) We explicitly introduce the issue of endogenous coalition formation. More in detail, we use the partitioned game approach of the endogenous coalition formation literature. This approach consists in reducing a game in normal form to a two-stage game (a partitioned game). In the first stage policymakers try to form coalitions among themselves by playing non-co-operatively according to different possible assumptions (to which correspond different equilibrium concepts). Afterwards, in the second stage of the game, the coalitions formed (or the singletons) play non-co-operatively in setting their stabilisation policies to face a macroeconomic shock. However, the partitioned approach has a limitation. Once coalitions are formed, they cannot change.[6] Therefore, binding agreements must be assumed in the second stage of the game.

(c) In this paper we also extend the current literature on the institutional design (*ex-ante* co-ordination) of the EMU by taking account of a dynamic framework. After solving the n-country model analytically according to the standard linear-quadratic methodology based on the reduced form of the model, we expose the main features of our model by numerical simulations based on structural form parameters. In the numerical simulations, we will analyse the consequences of *ex-ante* and *ex-post* policy co-ordination under different assumptions on the sign and size of the fiscal spillovers, and on the asymmetries among Member States. The different forms of asymmetry that will be investigated are: countries having asymmetric structural model parameters (model asymmetry), policymakers having different preferences (preference asymmetry), and, finally, shocks that asymmetrically hit countries (shock asymmetry).

The paper is organised as follows. Section 2 provides a small dynamic macro-economic model of the EMU economy and the dynamic stabilisation problem the fiscal policymakers and the common monetary authority are facing. Section 3 discusses in detail the institutional aspects of policy co-ordination in the EMU context and how these aspects are incorporated into our analysis. Section 4 analyses the consequences of *ex-post* and *ex-ante* policy co-ordination in a dynamic framework by studying numerical simulations of various examples. An Appendix is added with details on analytical and computational aspects underlying our analysis.

2 The basic economic framework

In this section we describe our basic framework. We consider a model where n countries ($\bar{N} := \{1, 2...n\}$) participate in a monetary union. Each economy is described by an aggregate demand/IS curve and an aggregate supply curve (derived from a Phillips relationship). All the variables are in logarithms, except for the interest rate which is in perunages, and denote deviations from their long-run equilibrium that has been normalised to zero, for simplicity. A dot above a variable denotes its time derivative.

Equations (1) are the IS curves which represent the aggregate demand (AD) in each of the EMU countries as a function of competitiveness in *intra*-EMU trade, the domestic real interest rate, the

[5] Evidence of foreign inflation effects on the Phillips curve is provided by DiNardo and Moore (1999). See also Razin and Yuen (2001) and Di Bartolomeo *et al.* (2003).

[6] This is in accordance with the open-loop Nash solution concept utilised in this paper.

foreign real output gaps, and the domestic real fiscal deficit. Hence, the aggregate demand satisfies:

$$x_i(t) = -\gamma_i \left[i_E(t) - \dot{p}_i(t) \right] + \eta_i f_i(t) + \sum_{j \in \bar{N}/i} \rho_{ij} x_j(t) + \sum_{j \in \bar{N}/i} \delta_{ij} \left[p_j(t) - p_i(t) \right] \tag{1}$$

in which x denotes the real output gap (defined as real output relative to potential real output[7]), f the real fiscal deficit, p the price level, and i_E the common nominal interest rate in the EMU area. The (expected) real interest rate is defined as the difference between the nominal common interest rate and the (expected) inflation in a country[8]. Although the nominal interest rate is the same for the whole Euro area, real interest rates diverge among countries if inflation rates are different.

Equations (2) are open-economy Phillips curves, which describe the aggregate supply (AS) in each of the EMU countries:

$$\dot{p}_i(t) = \zeta_i x_i(t) + \sum_{j \in \bar{N}/i} \varsigma_{ij} \dot{p}_j(t) \ , \quad p_i(0) = p_{i0} \tag{2}$$

Aggregate supply is assumed to be determined by a Phillips curve implied by the existence of some (nominal) rigidities in the goods (and/or labour) markets giving rise to a short-run trade-off between inflation and output. In this Phillips relationship the inflation rates of the other countries play a role since it is assumed that a real wage wedge between the real wage relevant for the domestic firms (based on the producer price index) and that relevant for the trade unions (based on the consumer price index) exists. In accordance with our short-run stabilisation focus, the effectiveness of fiscal policy is limited to its transitory impact on the output gap through the induced stimulus of the aggregate demand. The initial values of domestic prices represent (initial) level shocks that hit the economy at time zero. In this setting both symmetric and asymmetric price shocks can be considered.

Within the above economic framework, we assume that the fiscal authorities control their fiscal policy instrument such as to minimise the following quadratic loss function[9], which features domestic inflation, real output gap, and real fiscal deficit, with respect to the control variable f_i:

$$J_i(t_0) = \frac{1}{2} \int_{t_0}^{\infty} \{ \alpha_i \dot{p}_i^2(t) + \beta_i x_i^2(t) + \chi_i f_i^2(t) \} e^{-\theta(t-t_0)} dt \tag{3}$$

in which θ denotes the rate of time preference and α_i, β_i, and χ_i represent preference weights that are attached to the stabilisation of inflation, output, and fiscal discipline, respectively (in general, $\beta_i > \alpha_i$). In particular, parameter χ_i is an indicator for the stringency of the rules imposed by the SGP. A higher value of χ_i in this interpretation means that the SGP is more strictly interpreted and high deficits bear high costs.

We choose the EMU-wide nominal interest rate as the ECB's monetary policy instrument and add an interest rate smoothing objective in the ECB's cost function, to express the ECB's caution in setting monetary policy. Consequently, we assume that the ECB is confronted with the minimisation of the following loss function:

$$J_E(t_0) = \frac{1}{2} \int_{t_0}^{\infty} \left\{ \left(\sum_{i=1}^{n} \alpha_{iE} \dot{p}_i(t) \right)^2 + \left(\sum_{i=1}^{n} \beta_{iE} x_i(t) \right)^2 + \chi_E i_E^2(t) \right\} e^{-\theta(t-t_0)} dt \tag{4}$$

[7] In this paper, it is assumed that the equilibrium real output gap has been normalised to zero for convenience.

[8] We have assumed that expected inflation equals actual inflation in (1). Given the deterministic nature of the model, this amounts to assuming perfect foresight.

[9] Note that the quadratic form of the loss function implies that policymakers are equally concerned about inflation and deflation and about a negative output gap vs. a positive one. This may not always be realistic; however, such an assumption is necessary to keep the analysis more tractable.

The minimisation of this loss function w.r.t. $i_E(t)$ is consistent with the derivation of a standard monetary policy rule (see e.g. Clarida *et al.* (1999)), since it results in a linear function in its arguments.

The structural form model (1)-(2) can be transformed into the following reduced form model:[10]

$$\begin{bmatrix} x(t) \\ \dot{p}(t) \end{bmatrix} = \begin{bmatrix} D & E & M \\ A & B & N \end{bmatrix} \begin{bmatrix} p(t) \\ f(t) \\ i_E(t) \end{bmatrix} \tag{5}$$

where $x(t)$ is a country-ordered vector of output gaps, $\dot{p}(t)$ is a country-ordered vector of inflation rates, $p(t)$ and $f(t)$ are the price level and fiscal deficit vectors, respectively.[11] The partitioned matrix $L := \begin{bmatrix} D & E & M \\ A & B & N \end{bmatrix}$ indicates the elasticities of the real output gap and inflation with respect to price levels and control instruments. The upper part of matrix $L \in \mathbb{R}^{2n\times(2n+1)}$ indicates the instantaneous elasticities of the real output gaps. The lower part of this matrix indicates the elasticities of the inflation dynamics of the model. The matrix L is crucial in the analysis of the externalities. More in detail, the matrix $E \in \mathbb{R}^{n\times n}$ describes the effects of the domestic fiscal policy on the domestic real output gaps (main diagonal elements) and those of the foreign fiscal policies on the domestic real output gaps (off-diagonal elements); the latter elasticities are called fiscal externalities. Similarly, the matrix $B \in \mathbb{R}^{n\times n}$ describes the effects of the fiscal policy variables on the inflation rates. Matrices $D \in \mathbb{R}^{n\times n}$ and $A \in \mathbb{R}^{n\times n}$ indicate the effects of domestic and foreign price levels on the domestic real output gaps and inflation rates, respectively. Vectors $M \in \mathbb{R}^n$ and $N \in \mathbb{R}^n$ are the semi-elasticities of the real output gaps and inflation rates w.r.t. to the common nominal interest rate.

3 Externalities and the institutional setup

3.1 Shocks and externalities

In most cases the debate on the desirability of international policy co-ordination focuses on the magnitude and the signs of the fiscal spillovers that could justify a more co-operative approach to demand-oriented fiscal policies. A further (recently introduced) aspect is related to the action of the ECB, which can neutralise the effects of fiscal co-operation if its targets are opposed to those of the national governments (see Beetsma and Bovenberg (1998) and Acocella and Di Bartolomeo (2001)).

The sign and size of fiscal externalities are particularly important as they ultimately determine how large such effects of fiscal spillovers are (in absolute terms) and whether co-ordination should lead to a more expansionary or more restrictive fiscal stance in the Member States (Beetsma *et al.* (2001), pp. 4-5).

The theoretical literature does not provide a clear-cut answer about the sign of these externalities. The main channels of the effects of the domestic fiscal expenditure externalities on foreign real output gaps are from the terms of trade (negative), the real interest rate (negative), and external demand (positive) spillovers (Levine and Brociner (1994)). Overall, the validity of the argument in favour of negative externalities primarily depends on the empirical importance of intra-EMU terms-of-trade effects and on the reaction of the common interest rate to changes in fiscal policy. In most of the theoretical models, terms-of-trade effects are significant because they implicitly assume strategic interaction(s) within a group of large countries making up the world economy. However, according to Beetsma *et al.* (2001), the EMU is better described as a club of small economies open to the rest of the world. More specifically, the goods exchanged among EU Member States are also traded at the world level, a level at which individual EU economies can be assumed to be small in the trade-theoretic sense.

[10] See the Appendix for the derivation of the reduced form of the model.

[11] Clearly, the dimension of all these vectors is n.

Fiscal policy affects not only domestic and foreign real output gaps but also domestic and foreign inflation. Therefore, externalities may also emerge from the fiscal authorities' behaviour through the inflation channel. Fiscally-induced inflation externalities also raise a new issue in the EMU context, namely the interplay of the ECB with the national fiscal authorities and possible conflicts associated with different policymakers' preferences. Moreover, many of the results of the policy co-ordination literature based on two-country models (the "two-is-many" principle) are not valid when a third player is considered (see Rogoff (1985) and Kehoe (1989)). In our context, the natural "third player" is the ECB[12] and, considering the explicit separation of monetary and fiscal authorities, conflicts among the national governments about the orientation of the macroeconomic policy mix are often inevitable.[13] A potentially large discrepancy between the objectives of the ECB and those of the national governments is a serious and permanent source of tension, in addition to possible conflicts due to different cyclical or structural conditions (see Debrun (2000) and Acocella and Di Bartolomeo (2001)).

Besides the interpretation of the matrix L as a matrix of externalities, the initial shock structure has to be taken into account. Actually, each policymaker reacts to an initial shock. However, the policy actions also affect the other countries and imply a feedback from them. This feedback will be determined by the effects of the monetary and fiscal policies from the other countries and these effects are captured by matrix L too.

3.2 Institutional setup and co-operative mechanisms

The current policy framework of the EMU presents a strong asymmetry between the management of fiscal and monetary policies. The common monetary policy is determined by a supranational policymaker (the ECB) with a statutory primary objective, achieving and maintaining price stability in the EMU area. On the contrary, fiscal policies remain in the hands of the Member States, with no objective specified by the Treaty but constrained by the SGP-requirements. This decentralised management of the fiscal policies raises several issues on the need of *ex-post* co-ordination among Member Governments and the eventual alternative mechanisms that can guarantee *ex-ante* co-ordination.[14]

The *ex-ante* co-ordination among fiscal policymakers can be implemented according to positive or negative mechanisms. In the EU the only positive mechanism for fiscal policy co-ordination (*positive co-ordination*) is the use of the BEPGs, which, however, are mostly used as non-binding recommendations prepared by the EC and adopted by the *ECOFIN Council* each year. Assuming negative fiscal externalities, a negative mechanism for fiscal co-ordination (*negative co-ordination*) is based on the sanctions in the case of excessive deficits from the SGP. The SGP allows the ECB to "play on the safe side" by putting a strong limit to the discretional power of the national governments in setting their independent fiscal policies (Onorante (2002)).

In the ongoing debate, it is argued that increased co-ordination should include 1) a greater sharing of information among the Member States, 2) a greater positive co-ordination, and 3) a progressive reduction of the importance of negative (rule-based) co-ordination.[15]

In this paper the institutional design issue and *ex-ante* positive co-ordination are introduced by assuming that policymakers, who face a stabilisation problem in the EMU, play a two-stage game. In the first stage (the coalition game) they decide non-co-operatively whether or not to co-ordinate their fiscal policies after that common or country-specific shocks have been observed. In the second stage

[12] See e.g. Agell *et al.* (1996), Jensen (1996), Beetsma and Bovenberg (1998), and Acocella and Di Bartolomeo (2001).

[13] According to Beetsma *et al.* (2001), p. 6, "such conflicts are particularly relevant in the European context where the central bank has a mandate to focus primarily on price stability. This is certainly narrower than the mandate given to the national governments by their electoral constituencies."

[14] Although several studies have investigated the effects of (needs for) fiscal and/or monetary co-ordination, only a few have challenged the issue of the co-ordination mechanism by comparing alternative schemes (see e.g. van Aarle *et al.* (2002a) and Onorante (2002)).

[15] These guidelines are however not fully agreed. For example, Uhlig (2002) claims that SGP needs strengthening rather than weakening (so he calls for an increase of negative co-ordination).

(the stabilisation game) they play a non-co-operative dynamic game, where those policymakers, who have signed the agreement, play as a single player sharing a common loss function. The rules of the first-stage game determine the institutional setup (*ex-ante* co-ordination) whereas the second stage of the game describes *ex-post* co-ordination. According to the rules determined in the institutional co-ordination negotiations, different coalition structures may emerge when *ex-post* co-ordination is considered. Negative co-ordination is determined by the magnitude of the costs associated with the fiscal stance prescribed by the SGP.

In the first stage of the game, we restrict our attention to four alternative institutional settings. Different setups are associated with different stylised institutional setups characterised by different bargaining powers, procedures, rules, and available information among policymakers.[16]

1. We first consider an equilibrium where decisions about fiscal policies are determined by the national governments and fiscal co-ordination is arranged by multilateral agreements determined according to the following procedure. All policymakers simultaneously face the problem of accepting or rejecting a proposal that consists in sharing their loss functions when setting their fiscal policies. After that all agents' decisions are taken, the equilibrium is formed. In game theory this equilibrium concept is formalised as the *Coalitional Nash Equilibrium* (CNE).[17] This institutional setup is probably the closest to the current institutional setting of the EMU based on decentralised fiscal policymakers.

2. Second, we consider an institutional setup driven by an equilibrium where decisions about economic policies are determined entirely at the EMU level by an institutionalised and centralised *Eurogroup,* which decisions are binding for the national governments (full co-operation setup with co-ordination of fiscal and monetary policies; the corresponding full-co-operative equilibrium is denoted by C).

3. Third, we assume that decisions about fiscal policies are determined by the national governments and that co-ordination is built on the basis of a hierarchical sequential negotiation process (*Sequential Negotiation Equilibrium,* SNE).[18] This mechanism emphasizes the possible role played by single countries in the negotiation for achieving a co-ordination agreement, e.g. that with the temporary EU President Country. In this case, the EU Presidency determines a list of proponents (list of order) among the Member Country Ministers, and then each minister, according to this list of order, proposes a coalition to a group of countries. Countries that accept a proposal exit from the game. An equilibrium of such a negotiation scheme is an SNE. In the Appendix we describe an algorithm for the computation of a unique SNE. This mechanism

[16] See van Aarle *et al.* (2002b) for a first exploratory treatment of these (dynamic) coalitional equilibria concepts.

[17] The CNE is the most common Nash equilibrium concept in the coalition formation literature. It was first introduced by the seminal studies of d'Aspremont *et al.* (1983) in the industrial organization literature. A CNE is an equilibrium of a one-shot game where each agent faces the problem of simultaneously accepting or rejecting a proposal that consists in sharing her utility function only by looking at the immediate consequence of her actions. After that all agents' decisions are taken, the CNE is formed. This equilibrium is fully characterised by the fulfilment of two stability conditions and a profitability condition. The stability conditions assure that no policymaker has an incentive in deviating from its strategy by entering in an existing coalition (external stability) or leaving an existing coalition (internal stability). Profitability means that the coalition members incur a loss which is lower than that they would get when all players would act as singletons (i.e. when they play non-co-operatively).

[18] See e.g., Bloch (1996) and Ray and Vohra (1999). An SNE is an equilibrium of a hierarchical multi-stage negotiation process. The negotiation starts with one policymaker who proposes a coalition. The order of agents that can propose a coalition is given by an exogenous rule (i.e. a rule of order). Each prospective member can reject or accept the proposal in the order determined by this fixed rule. If one of the policymakers rejects the proposal, that policymaker must make a counter-offer. If all members accept, the coalition is formed and then all members of that coalition withdraw from the negotiations. When all agents exit from the negotiation the SNE is formed. Hence, one player after the other decides to propose a coalition to the other players. These decisions are determined by non-cooperative best-reply rules, given the coalition structure and the allocation in the previous rounds. One of the nice features of this approach is that it might explain in terms of history why specific stable coalitions are reached among the many possible ones. In other words, the importance of historical relationships between nations might be captured by this approach.

has, however, several drawbacks. The most important of them is that the outcome can depend on the list of order, and, therefore, an institutional question arises: 'Who determines that list, since the list order can be chosen strategically in order to determine a possible coalition?'

4. Finally, we consider the possibility of reaching final decisions about co-ordination on the basis of a sequentially repeated negotiation process that ends when there are no further opportunities of gains for the players (*Farsighted Coalitional Equilibrium*, FCE).[19] This equilibrium is supported by an institutional framework where a lot of information circulates among EU policymakers. The importance of information sharing among the EU Member States to implement co-ordination is stressed by Onorante (2002). Moreover, it is also related to the ECB transparency. In fact, notwithstanding the ECB's own insistence about its transparency[20], a debate persists on the level of its accountability and transparency (see e.g. Issing (1999)). Specifically, this equilibrium implies that Member States and the ECB can forecast the reactions of (the) other policymakers to their actions, given that they have enough information about the other policymakers' preferences and about the state of the whole EMU area.

To summarise, the role played by single countries is ultimately determined by the institutional rules which govern the EMU. In our model, the *ex-ante* co-ordination problem takes the form of the endogenous coalition formation process introduced above. The imposition of the fiscal and monetary stringency rules provided by the SGP and the Maastricht Treaty clearly leads the institutional framework and constrains the fiscal and monetary policies. As discussed in Section 2, these requirements (and the degree of strictness with which they are interpreted) are introduced in the various policymakers' objectives.

4 Numerical solutions of the model

As a consequence of fixed bilateral exchange rates, asymmetric shocks have long been seen as the major problem for the EMU (see Favero *et al.* (2000)). It is generally argued that this kind of externalities can be coped by structural reforms that have been advocated to improve flexibility on product and labour markets. However, an alternative way resides in the adoption of co-ordinated policies among EU Member countries. In our model different forms of asymmetry can be considered: countries may have asymmetric structural model parameters (model asymmetry), policymakers may have different preferences (preference asymmetry), policymakers may have different bargaining powers in negotiating co-operative agreements (power asymmetry) and, finally, shocks may asymmetrically hit countries (shock asymmetry).

When analysing the different cases of asymmetries, we may compare the positions of e.g. Buti and Sapir (1998) and Beetsma *et al.* (2001), but now in a dynamic and possibly asymmetric model setting. Buti and Sapir (1998) argue that fiscal co-ordination is desirable when large symmetric shocks are present, while Beetsma *et al.* (2001) argue that fiscal co-ordination is desirable when there are asymmetric shocks, because fiscal authorities can internalise opposite fiscal policies when trying to offset each other's effect.[21] In our numerical simulations, we will consider several of the

[19] More in detail, the FCE is a multi-stage negotiation procedure based on the idea of indirect domination, which implies farsightedness (see e.g. Chwe (1994) and Mariotti (1998)). The indirect domination concept captures the idea that each agent (or coalition of agents), who deviates from a given coalition structure, has anticipated further deviations of the other agents. Hence, an FCE is defined as an equilibrium where players foresee the reaction of the other players to their actions.

More information (including specific mathematical properties) on the various equilibrium concepts discussed in this paper can be found in Di Bartolomeo *et al.* (2002a).

[20] See e.g. ECB (1999), p.43.

[21] Note also that the analyses of Buti and Sapir (1998) and Beetsma *et al.* (2001) are mainly limited to *ex-post* co-ordination in a static setting only.

above mentioned asymmetries; however, we start by describing our benchmark model: a symmetric three-country model.[22]

4.1 *Symmetric benchmark model*

The baseline parameters used in the simulations are listed in Table 1. Although countries are assumed to be symmetric with respect to all the structural form parameters, policymakers' preferences are not symmetric. The ECB's preference differs from that of the (identical) national governments (preference asymmetry). The difference is relevant since, according to common evidence, we assume that the ECB puts a larger weight on inflation with respect to output gap than the EMU Member States do.

Table 1 – Baseline parameters $(i, j \in \{1, 2, 3\}, i \neq j)$[23]

$\eta_i = 1$	$\delta_{ij} = 1$	$\gamma_i = 0.7$	$\zeta_i = 0.4$	$\rho_{ij} = 0.1$	$\varsigma_{ij} = 0.1$
$\alpha_i = 3$	$\beta_i = 7$	$\chi_i = 1$	$\alpha_{iE} = 7$	$\beta_{iE} = 3$	$\chi_E = 1$

Given the parameters of Table 1, the matrix of reduced form coefficients in this first scenario ($L_{(1)} := \left[\begin{array}{c|c|c} D_{(1)} & E_{(1)} & M_{(1)} \\ \hline A_{(1)} & B_{(1)} & N_{(1)} \end{array}\right]$) is computed as (see Appendix):

$$L_{(1)} = \left[\begin{array}{ccc|ccc|c} -2.3656 & 1.1828 & 1.1828 & 1.5293 & 0.3465 & 0.3465 & -1.5556 \\ 1.1828 & -2.3656 & 1.1828 & 0.3465 & 1.5293 & 0.3465 & -1.5556 \\ 1.1828 & 1.1828 & -2.3656 & 0.3465 & 0.3465 & 1.5293 & -1.5556 \\ \hline -0.8802 & 0.4301 & 0.4301 & 0.6571 & 0.2270 & 0.2270 & -0.7778 \\ 0.4301 & -0.8802 & 0.4301 & 0.2270 & 0.6571 & 0.2270 & -0.7778 \\ 0.4301 & 0.4301 & -0.8802 & 0.2270 & 0.2270 & 0.6571 & -0.7778 \end{array}\right]$$

Since $E_{(1)}$ and $B_{(1)}$ contain only positive off-diagonal elements, the setting is characterised by positive fiscal externalities on the real output gaps (i.e. increases in the domestic fiscal deficit raise foreign output gaps) and negative fiscal externalities on the inflation rates (i.e. increases in the domestic fiscal deficit raise foreign inflation). Moreover, increases of domestic fiscal expenditures raise both the domestic real output gaps and inflation rates.

We first consider a common price shock (p_0) that hits the whole EMU area (with an equal size). Optimal losses are described in Table 2. NC indicates the non-co-operative regime, C the full co-operation regime, F the coalition between all the fiscal authorities, and terms between brackets are the partial coalitions among fiscal authorities.

Table 2 - Optimal losses from a common shock ($p_0 = [1, 1, 1]'$)

	NC	C	F	$(1,2)$	$(1,3)$	$(2,3)$
Country 1	0.1166	0.0299	0.6366	0.3079	0.3079	0.1314
Country 2	0.1166	0.0299	0.6366	0.3079	0.1314	0.3079
Country 3	0.1166	0.0299	0.6366	0.1314	0.3079	0.3079
ECB	1.9399	1.7475	3.0580	2.2062	2.2062	2.2062

The sole regime that assures losses that are lower than those associated with the non-co-operative case is the full co-ordination solution (grand coalition C) between fiscal and monetary authorities (in more technical terms, full co-ordination is the only profitable regime). All forms of fiscal co-ordination

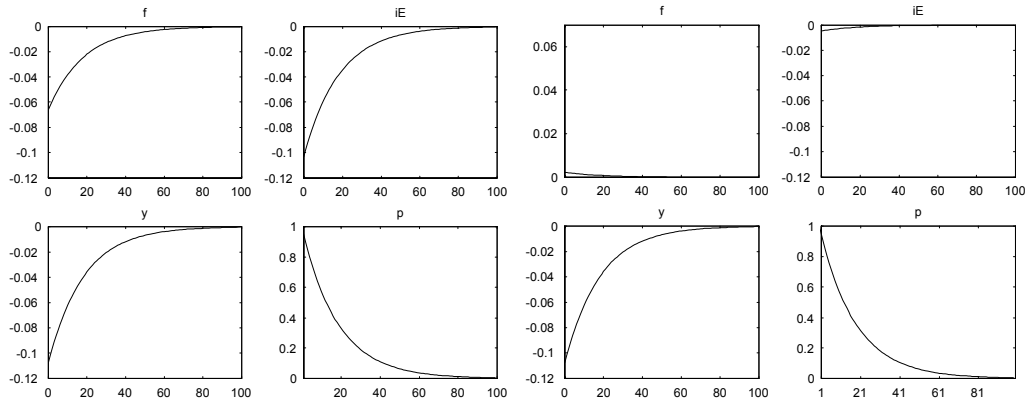
[22] An algorithm that explains how to solve the model for the general n-country case is provided in the Appendix.

[23] In all the simulations we have used symmetric bargaining powers and a discount rate (θ) equal to 0.04. Robustness of the results has been tested by many additional non-reported numerical simulations.

are associated with negative performances (i.e. coalition members have losses higher than those that they achieve in the complete non-co-operative regime), so they are non-profitable. In this symmetric case, negative fiscal externalities prevail and partial co-ordination of fiscal policies has a negative effect. It is easily verified that all the coalitional equilibria coincide and that the full co-operative case C is the single equilibrium; hence, CNE=SNE=FCE= C.[24]

Figure 1 provides the macroeconomic adjustments in the non-co-operative regime (panel (a)) and the full co-operative case (panel (b)), induced by the common shock (because of the symmetry only the results for one country are presented).

Figure 1



(a) Non-co-operative (b) Full co-operation

In this example, fiscal authorities try to improve competitiveness vis-à-vis the other countries with restrictive fiscal policies, but since all countries follow the same policy the final losses in the non-co-operative regime are higher than in the co-operative one. Therefore, fiscal policies in the non-co-operative case tend to induce a recession, and the ECB reacts by cutting the nominal interest rate to stimulate the economies. The different losses between the two regimes are mainly associated with the different management of the policies. Output gaps and prices adjust practically in the same manner, but policy strategies are largely different. In the non-co-operative regime, in fact, fiscal authorities tend to neutralize mutual effects on competitiveness, whereas the ECB tends to neutralize the deflationary and recessive effects of fiscal policies.[25] In the co-operative regime all policymakers internalise the negative externalities from their policy management. The co-operative regime disciplines the management of the fiscal policies so that countries pursue moderate fiscal expansions and end up with small deficits.

Note that the above analysis matches the case studied by Buti and Sapir (1998), i.e. a common (price) shock is applied, but our result contrasts with their outcome because the fiscal coalition F is associated with a higher loss. However, our result does not confirm the result of Beetsma *et al.* (2001) either, since the full co-ordination regime C improves the welfare for all policymakers. The reason is that, according to Figure 1, policymakers internalise the negative externalities associated with non-cooperative policies.

Considering a country-specific shock structure radically changes the above results. We consider two country-specific price shocks that affect the prices in country 1 and 3 in an opposite manner (an

[24] Results of Table 2 are quite robust with respect to *ceteris paribus* changes in the parameters. Only for very high values of ρ (e.g. $\rho = 1.73$, $\eta = 1$) or low values of γ (below 0.17 for $\eta = 1$), we observe a different pattern where the non-co-operative solution prevails.

[25] With a (symmetric) negative price shock ($p_0 = [1, 1, 1]'$) fiscal policy is restrictive (a surplus) and monetary policy is expansionary (a negative interest rate differential), while with a (symmetric) positive price shock ($p_0 = [-1, -1, -1]'$), we have the same (optimal) losses but with opposite policies: a restrictive monetary policy and an expansionary fiscal policy. In the latter case the fiscal authorities will tend to spend too much and with co-ordination they will reduce their expenditures.

asymmetric country-specific shock). Optimal losses for the various regimes are reported in Table 3.

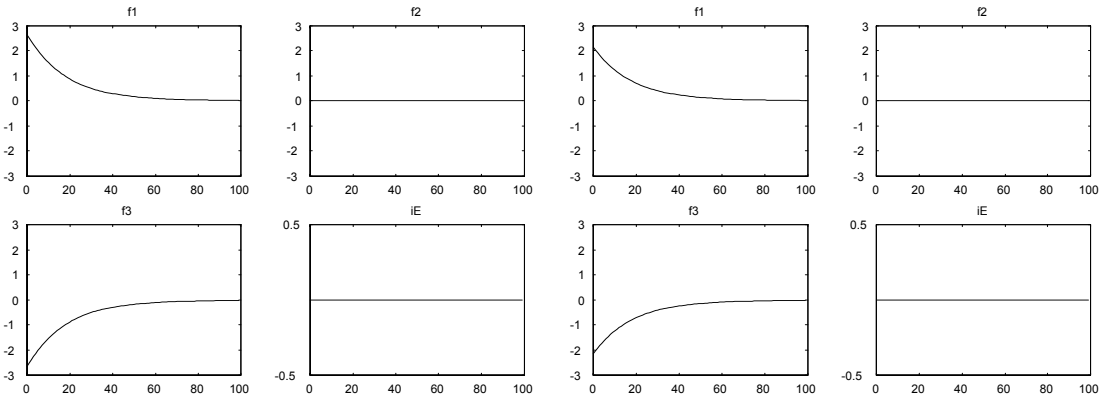
Table 3 – Country-specific shock ($p_0 = [1, 0, -1]'$)

	NC	C	F	$(1,2)$	$(1,3)$	$(2,3)$
Country 1	12.1117	7.8730	7.8730	13.8359	7.8730	9.5498
Country 2	0	0	0	3.7214	0	3.7214
Country 3	12.1117	7.8730	7.8730	9.5498	7.8730	13.8359
ECB	0	0	0	1.1428	0	1.1428

The most evident feature of Table 3 is that there are no differences in optimal losses between the grand coalition C, the full fiscal coalition F, and the partial coalition $(1,3)$. This occurs because the fiscal policy of the first country is exactly offset by the fiscal policy of the third country, due to the model symmetry and the preference symmetry among fiscal authorities.[26] More in detail, in regimes where countries 1 and 3 are either both in the same coalition or both outside, due to the equal sizes of the perfectly opposite shocks, the ECB does not affect the dynamics of the game since changes in the common nominal interest rate equally affect all the prices and output gaps. Results dramatically change when partial fiscal coalitions with country 2 are formed, even in this symmetric setting. With the partial fiscal coalitions $(1,2)$ and $(2,3)$ all the players, including the ECB, are directly affected in their optimal policies and losses. Coalitions including both countries 1 and 3 are clearly equilibria of the game since they correspond to the first best strategies for all the players. Hence, SNE= C, CNE= $C, F, (1,3)$ and the Rational Feasible Coalitions set of FCE = $C, F, (1,3)$.[27]

Figure 2 shows the paths of the control variables after the country-specific shock. Again symmetries have a neutralising effect and tend to compensate the effects of the policymakers' actions. Co-operation helps in reducing the losses from too expansionary (restrictive) fiscal policies: in the co-operative case country 1 has a smaller deficit and country 3 a smaller surplus than in the non-cooperative case. In this way negative fiscal externalities are internalised and, therefore, partially reduced. Because of the perfect structural symmetry of the model, country 2 and the ECB are not affected at all by the shocks in country 1 and 3.

Figure 2



(a) Non-co-operative regime (b) Full and fiscal co-operation regimes

[26] See van Aarle *et al.* (2002a) for a more detailed description of this mechanism in a two-country model.

[27] The full coalition C is the sole SNE equilibrium of the game as it is assumed according to the algorithm in the Appendix that in case of equal losses the players will choose that coalition that contains the highest number of players. A similar reasoning can be applied for the FCE, where it is assumed that in the case where the Rational Feasible Coalitions set consists of more than one regime, the players will look for an exogenous system to choose the final coalition (see the algorithm to compute SNE and FCE equilibria in the Appendix).

Notice that the asymmetric country-specific shock analysed in Table 3 is the case which Beetsma *et al.* (2001) analyse and find that fiscal co-ordination is desirable. We confirm their result: fiscal authorities internalise the negative effects of opposite policies with co-ordination. But, we also find that, in this symmetric setting, no further gains are associated with full co-operation C, which is confirmed by Figure 2 (no more effects to internalise).

The above model seems to advocate a need for co-ordination. We can distinguish two cases. First, when a common price shock is considered, full co-ordination of economic (monetary and fiscal) policies is required to internalise the externalities. Second, when country-specific shocks occur, co-ordination needs become weaker since only fiscal co-ordination among countries, hit by the shocks, is needed.

However, the above results are based on a reduced form characterised by $L_{(1)}$. Taking a different set of parameters into account, where e.g. negative fiscal externalities on real output gaps are considered instead of positive ones, we obtain a more robust picture of the above results. Assuming $\varsigma_{ij} = 0.6$ (for all i and $j \in \{1,2,3\}$ with $i \neq j$), we get a different reduced form $L_{(2)}$ where $E_{(2)}$ is equal to $\begin{bmatrix} 0.8722 & -0.2088 & -0.2088 \\ -0.2088 & 0.8722 & -0.2088 \\ -0.2088 & -0.2088 & 0.8722 \end{bmatrix}$, and therefore, negative fiscal externalities with respect to real output gaps hold. In this and several other (non-reported) simulations, we observed that the findings of Table 2 are quite robust even if negative fiscal externalities dominate[28] (which seems to be the case in the EMU, although caution needs to be expressed since little econometric evidence is available (see footnote 2)).[29]

4.2 *Ex-ante co-ordination (symmetric setting)*

In the benchmark model of section 4.1 we have discussed mainly *ex-post* policy co-ordination in our numerical simulations. Now, we want to study the consequences of different forms of *ex-ante* co-ordination in more detail.

We do this in Table 4 that contains results based on the reduced form $L_{(1)}$. The following (asymmetric) price shock is assumed: $p_1(0) = 1$, $p_2(0) = -1$, and $p_3(0) = 1$.

Table 4 – Country-specific shock ($p_0 = [1, -1, 1]'$)

	NC	C	F	$(1,2)$	$(1,3)$	$(2,3)$
Country 1	5.1464	3.4654	3.3142	4.2673	11.5036	3.9647
Country 2	22.0439	14.0739	14.5786	18.2389	17.5804	18.2389
Country 3	5.1464	3.4654	3.3142	3.9647	11.5036	4.2673
ECB	0.2155	0.1942	0.3398	0.9281	1.9266	0.9281

Table 4 shows a different and more problematic scenario in this case of a country-specific shock. In fact, full policy co-ordination (C) assures a better result than that of the non-co-operative (NC) regime. However, although the full co-operative regime is profitable and *Pareto-optimal*, it is not internally stable. Hence, C is not an equilibrium of the game (and hence not the CNE). In fact, the non-co-operative regime is the CNE of the game. The reason of this is simple. Considering the full co-operative regime, the first and the third countries have an incentive to deviate from the co-operative strategy since their loss in the full fiscal coalition (F) case is lower. However, also country 2 has an incentive to deviate from the full fiscal coalition that, therefore, cannot be an equilibrium.

[28] In the case of negative fiscal externalities, modifications of parameters η and δ do not change the coalitional outcome. However, for $\xi > 0.53$ and $\gamma < 0.3$ (other parameters not changed) the full coalition is not an equilibrium any longer.

[29] Cases with positive externalities are (extensively) studied in Di Bartolomeo *et al.* (2002b).

For the same reason, partial coalitions cannot be an equilibrium so, notwithstanding its inefficiency, the non-co-operative regime is the sole CNE of the game.

Since the NC-solution is Pareto-inferior with respect to most coalitional outcomes, it is interesting to look for different mechanisms that support co-ordination. The inefficiency that emerges from Table 4 is related to the mechanism considered in the coalition formation. Different mechanisms can eliminate it. The institutional co-operative design where policymakers act determines the rules of the coalition formation process (Ecchia and Mariotti (1997)). For instance, using the algorithm of the Appendix for the SNE the resulting equilibrium will be the full policy co-operative equilibrium (C) since each proponent has an interest in proposing full policy co-ordination because it is the only one that will be accepted by the others. In other words, countries 1 and 3 know that in this case the full fiscal coalition (F) will never be proposed; therefore, they will accept the grand coalition that assures a lower loss than that associated with the non-co-operative regime. Also, the FCE of the dynamic game includes the full co-operative regime (see the Appendix for details)[30]. However, a mechanism which implies the FCE requires more information than one that supports the SNE or the CNE. For instance, the FCE is not compatible with a central bank that is not transparent or with an environment where credible information about the state of the economies of the Member Countries is not available. If the same Member States have to provide information about their economy they can try to use this information strategically, and, therefore, the FCE may not characterise such a situation (a similar observation can be made for information provided by the ECB).

Our last example stresses that, even when co-ordination gains are present, co-operative solutions do not necessarily emerge as an equilibrium of the game. Different institutional setups (*ex-ante* co-ordination) imply different equilibria. Therefore, rules, procedures and available information are sometimes crucial to improve co-operative solutions and to raise the welfare of all the policymakers avoiding a free-riding behaviour. Table 4 emphasizes the relevance of the institutional setting design. According to the traditional CNE-mechanism, free-rider behaviour can lead to non-co-operative solutions (even if co-operation is Pareto-superior to non-co-operation). Hence, co-ordination mechanisms become more important. Various alternative (equilibrium) co-ordination mechanisms can be proposed to support co-operation: full co-operation (C), an SNE-mechanism (hierarchical), and an FCE-mechanism (farsighted). It is clear that the C-regime in Table 4 is SNE. The FCE algorithm does not provide a clear-cut answer, as the final set of Rational Feasible Coalitions for all players consists of both the C-and FC-regimes. Therefore, the final choice between these two regimes depends on exogenous factors as e.g. transfer system (see the Appendix for details on computations of equilibria).

Negotiation mechanisms and their outcomes are clear in the above example. However, less trivial cases may arise when more asymmetries are considered.

4.3 Ex-ante co-ordination (structural asymmetric setting)

The parameters of Table 5 can be interpreted as a setup where a large country (country 1) faces two small countries that are very sensitive to price changes. In addition, country 3 also imports inflation from the other countries ($\varsigma_{31} = \varsigma_{32} = 0.2$). In such a context we consider the following country-specific price shock: $p_1(0) = 1$, $p_2(0) = 0.75$, and $p_3(0) = 0.5$.

[30] The set of Rational Feasible Coalitions in the FCE algorithm consists of the C- and F-regimes. The final outcome depends on exogenous factors like e.g. the existence of a transfer system.

Table 5 – An example of a structural asymmetric setting

$\eta_1 = 1$	$\delta_{12} = 0.5$	$\gamma_1 = 0.7$	$\zeta_1 = 0.4$	$\rho_{12} = 0.1$	$\varsigma_{12} = 0$
$\eta_2 = 1$	$\delta_{13} = 0.5$	$\gamma_2 = 0.7$	$\zeta_2 = 0.4$	$\rho_{13} = 0.1$	$\varsigma_{13} = 0$
$\eta_3 = 1$	$\delta_{21} = 1$	$\gamma_3 = 0.7$	$\zeta_3 = 0.4$	$\rho_{21} = 0.4$	$\varsigma_{21} = 0$
	$\delta_{23} = 1$			$\rho_{23} = 0.4$	$\varsigma_{23} = 0$
	$\delta_{31} = 1$			$\rho_{31} = 0.4$	$\varsigma_{31} = 0.2$
	$\delta_{32} = 1$			$\rho_{32} = 0.4$	$\varsigma_{32} = 0.2$

The reduced form which corresponds to Table 5 (L_3) is characterised by the following matrix, that features positive fiscal spillovers for output gaps and negative ones for inflation:

$$L_3 = \begin{bmatrix} -0.7399 & 0.3115 & 0.4283 & 2.3364 & 0.8178 & 0.7788 & -2.7531 \\ 2.2975 & -2.6591 & 0.3616 & 3.2710 & 3.2877 & 2.2808 & -6.1877 \\ 2.3754 & -0.0979 & -2.2775 & 3.5514 & 2.6001 & 3.3267 & -6.6347 \\ -0.3160 & 0.1246 & 0.1713 & 0.9346 & 0.3271 & 0.3115 & -1.1012 \\ 0.9190 & -1.0836 & 0.1446 & 1.3084 & 1.3151 & 0.9123 & -2.4751 \\ 1.0748 & -0.2270 & -0.8678 & 1.8692 & 1.3685 & 1.5754 & -3.3692 \end{bmatrix}$$

The resulting losses are described in Table 6.

Table 6 – Asymmetric economic structure and country-specific shock

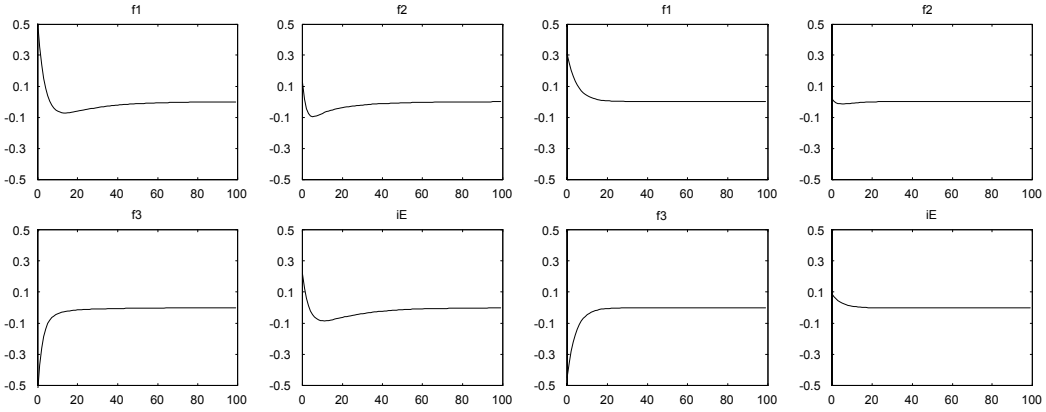
	NC	C	F	$(1,2)$	$(1,3)$	$(2,3)$
Country 1	0.8495	0.2595	3.2141	1.5506	1.1005	0.5601
Country 2	0.2324	0.0211	0.9217	0.3791	0.2611	0.9392
Country 3	0.9284	0.4693	1.6742	0.9259	0.9135	1.4012
ECB	1.3575	1.0527	4.7440	2.1305	2.1248	1.6007

Figures 3 and 4 display the adjustments of control and outcome variables in the non-co-operative and co-operative regimes. In the non-co-operative regime country 1 has a very expansionary policy since its output is now less affected by the terms of trade, whereas country 3 pursues a comparatively very restrictive fiscal policy, as an inflation importer. Country 2 is in between them, with initially expansionary fiscal policy, that eventually turns into a restrictive one.

Under full co-operation the policies follow practically the same pattern as in the non-co-operative case, but the intensity is more limited due to the internalisation of policy externalities. Especially the ECB turns up to be much less active in the interest-rate management. Since countries 1 and 2 have more limited expansionary fiscal policies, country 3, as an inflation importer, is able to pursue a less restrictive (anti-inflationary) fiscal policy. This is, however, optimal from the welfare perspective, which heavily penalises large fluctuations in the price level, like the rapid disinflation that occurs in

the non-cooperative regime.

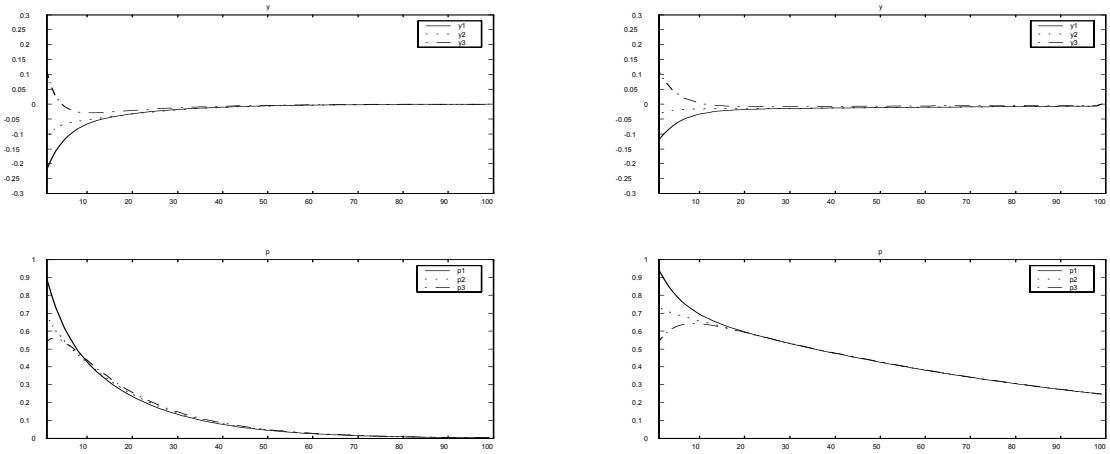
Figure 3 – Adjustments (controls)



(a) Non-co-operative regime (b) Full co-operative regime

The large country 1 faces the strongest negative price shock what causes the highest initial decline in the output. The case of country 3 is interesting, since its output grows initially due to greater competitiveness of domestic products caused by higher inflation rates in countries 1 and 2 (negative fiscal externalities). In the process of time, a restrictive fiscal policy, introduced partially due to inflation importing, makes the output gap in this country negative. In the co-operative case, a less restrictive policy of the ECB causes inflation in all countries to decline at a slower rate.

Figure 4 – Adjustments (outcomes)



(a) Non-co-operative regime (b) Full co-operative regime

It is easily verified that all the coalitional equilibria coincide and that the full co-operative case C is the single equilibrium (as being Pareto-superior), hence CNE=SNE=FCE = C (see the Appendix for details on computations of equilibria).

Table 7, based on the parameters of Table 5 (except for ,$\rho_{12} = \rho_{13} = 0.04$ and $\rho_{21} = \rho_{23} = \rho_{31} = \rho_{32} = 0.01$) describes the case of very low positive fiscal externalities from the demand side of the economy on the output gap, that is introduced by (rather drastic) changes in the parameter ρ. The submatrix $E_{(4)}$ for this case is equal to $\begin{bmatrix} 1.3929 & 0.0221 & 0.0206 \\ 0.0884 & 1.4007 & 0.0790 \\ 0.1975 & 0.1897 & 1.4022 \end{bmatrix}$.

Table 7 – Asymmetric country-specific shock with low fiscal spillowers

$\rho_{12} = \rho_{13} = 0.04$ and $\rho_{21} = \rho_{23} = \rho_{31} = \rho_{32} = 0.01$						
	NC	C	F	$(1,2)$	$(1,3)$	$(2,3)$
Country 1	0.4788	0.2690	0.5333	0.6254	0.3671	0.3933
Country 2	0.0627	0.0220	0.1057	0.1259	0.0513	0.1352
Country 3	0.4776	0.5124	0.5841	0.4395	0.5137	0.5822
ECB	1.1638	1.0528	1.4047	1.3364	1.1756	1.1383

This table shows that the fiscal spillovers have crucial importance for coalition outcomes of the game. Now, in contrast to the previous case, the non-cooperative regime is the only equilibrium of the game, as no coalition is profitable. Out of the institutional designs for co-operation examined here, none is able to promote policy co-ordination. The sole way to support full co-operation could be by introducing a transfer system: as countries 1, 2 and the ECB are better off in the full co-operative regime, they could agree to a transfer towards country 3 to compensate its losses from participating in the full co-operation equilibrium. However the study of such a transfer system is beyond the scope of this paper.

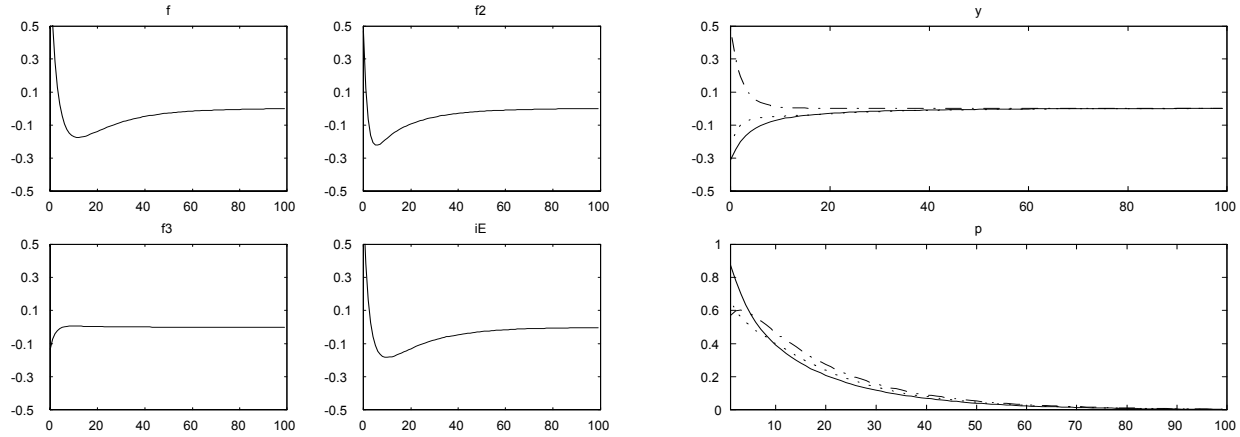
In Table 8 we assume that the inflation rates of countries 1 and 2 have an even stronger effect, than in Table 6, on the inflation rate of country 3. This also changes the equilibrium outcome, as similarly, there is no profitable coalition; hence, the non-co-operative regime is the only equilibrium (CNE = SNE = FCE = NC - see the Appendix for a detailed description of the algorithm). Just recall that with $\varsigma_{31} = \varsigma_{32} = 0.2$ in Table 6 full co-operation constituted the Pareto-superior equilibrium of the game. The full coalition cannot be sustained since country 3 has an incentive to deviate. The other players would prefer full co-operation but they suffer much higher welfare losses under non-co-operation.

Table 8 – Country-specific shock with a high inflation importer

Parameters as in Table 5 except for $\varsigma_{31} = \varsigma_{32} = 0.6$						
	NC	C	F	$(1,2)$	$(1,3)$	$(2,3)$
Country 1	2.9561	0.2587	17.0234	8.2460	4.2768	3.0079
Country 2	1.6041	0.0318	6.0395	2.3099	2.4818	2.1750
Country 3	0.2236	0.5870	4.7338	0.1954	0.9831	2.1569
ECB	3.3302	1.0300	21.7730	7.6625	6.1062	5.0858

Figure 5 describes the adjustments of control and outcome variables in the non-co-operative regime, such adjustments have clear similarities to Figures 3 and 4.

Figure 5 – Adjustments in the non-co-operative regime



(a) Controls (b) Output gaps, prices

Concluding this section we can state that in a structural asymmetric setting the optimal policies and the optimal outcomes become more complex. The magnitude of fiscal and inflation spillovers is crucial in determining the coalitional equilibrium (or equilibria) of the game. In general, the asymmetries reduce the gains from co-operation so that in many cases the full coalition cannot be supported without a transfer system (side-payments), which seems not to be very realistic in the EMU context.

4.4 *SGP stringency and ECB priorities*

In the context of our model we can also investigate the effects of two major policy institutions of the EU: (*i*) the SGP and (*ii*) the management of the monetary policy by the ECB. The SGP implies the accomplishment of fiscal targets by the BEPGs. In our model the effects of the SGP stringency can be studied by considering different weights associated with the domestic fiscal deficit (χ_i for $i \in \{1, 2, 3\}$). The effects of more restrictive thresholds imposed by different BEPGs are represented in Table 9. To enable comparisons with the benchmark model as found in Table 1, the numerical simulations in this section were based on the matrix of reduced form coefficients $L_{(1)}$.

Table 9 – SGP alternative thresholds ($\chi_i = 5$, 10, 15 for $i \in \{1,2,3\}$)[31]

χ_i	common shock [1,1,1]'						country-specific shock [1,0,-1]'					
	NC	C	F	(1,2)	(1,3)	(2,3)	NC	C	F	(1,2)	(1,3)	(2,3)
5	0.053	0.030	0.180	0.100	0.100	0.054	15.476	12.794	12.794	17.390	12.794	13.410
	0.053	0.030	0.180	0.100	0.054	0.100	0	0	0	2.593	0	2.593
	0.053	0.030	0.180	0.054	0.100	0.100	15.476	12.794	12.794	13.401	12.794	17.290
	1.754	1.748	1.818	1.770	1.770	1.770	0	0	0	0.157	0	0.157
	NC	C	F	(1,2)	(1,3)	(2,3)	NC	C	F	(1,2)	(1,3)	(2,3)
10	0.044	0.030	0.110	0.069	0.069	0.045	16.529	14.580	14.580	17.995	14.580	14.990
	0.044	0.030	0.110	0.069	0.045	0.069	0	0	0	1.909	0	1.909
	0.044	0.030	0.110	0.045	0.069	0.069	16.529	14.580	14.580	14.990	14.580	17.995
	1.745	1.748	1.765	1.750	1.750	1.750	0	0	0	0.054	0	0.054
	NC	C	F	(1,2)	(1,3)	(2,3)	NC	C	F	(1,2)	(1,3)	(2,3)
15	0.042	0.030	0.086	0.058	0.058	0.042	16.963	15.410	15.410	18.136	15.410	15.743
	0.042	0.030	0.086	0.058	0.042	0.058	0	0	0	1.527	0	1.527
	0.042	0.030	0.086	0.042	0.058	0.058	16.963	15.410	15.410	15.743	15.410	18.136
	1.743	1.748	1.753	1.746	1.746	1.746	0	0	0	0.028	0	0.028

In the common shock case, losses of fiscal policymakers are decreasing in the thresholds except for the initial equilibrium regime (C) that remains unchanged, regardless the increase in χ_i. Referring to the benchmark model analysis this result is easy to interpret. For $\chi_i = 5$ the full coalition (C) is the single equilibrium (CNE =SNE =FCE = C), as it enables to internalise negative externalities of fiscal policies and it is the sole profitable coalition. However, increasing SGP stringency makes co-operation relatively less necessary, as excessive fiscal policies are independently limited by each player. Already for $\chi_i = 10$ non-co-operation (NC) is the equilibrium of the game (although, this is due to the ECB's deviation from full co-operation).

It can be expected, that for even higher values of χ_i, in as well the non-cooperative case, and the full and partial fiscal coalitions cases, the losses of fiscal players will converge further to those of the full co-operative case. This happens because, in the optimal co-operative strategies, fiscal players use moderate fiscal expansions (see Figure 2).

In contrast to the common shock case, the fiscal policymakers' optimal losses increase in the country-specific shock ($p_0 = [1, 0, -1]'$) in all equilibria (C, F and $(1,3)$) with increasing fiscal stringency[32]. This is obvious, since SGP stringency makes the fiscal response to the asymmetric shock more limited. Therefore, in contrast to a common shock, excessive fiscal stringency in the form of the SGP is not desirable in the case of an asymmetric shock. However, one needs to keep in mind that the assumption of the symmetry of the countries is crucial in our analysis. The reason is the perfect off-setting of fiscal policies of both countries that experience exactly opposite shocks. In the presence of asymmetries between countries this conclusion might no longer hold[33].

To summarise, the above analysis shows that the increase of fiscal stringency is not desirable in case of a country-specific shock. However, in the case of a common shock, the negative (rule-based) co-ordination can diminish losses.

Consequences of different ECB's interest rate preferences are investigated in Table 10. The table tests the effects of different degrees of smoothing in the interest-rate management. Therefore, the

[31] Rows indicate optimal losses of governments for countries 1, 2 and 3, and the ECB, respectively. The first submatrix regards $\chi_i = 5$, the second submatrix $\chi_i = 10$, and, finally $\chi_i = 15$, for $i \in \{1,2,3\}$.

[32] Except for the ECB and country 2 whose losses equal 0.

[33] For example, when the structural asymmetric case of Table 5 is considered, increased fiscal stringency in the situation of a specific shock diminishes losses of all the players in the non-co-operative regime and increases losses for fiscal co-operation. For other regimes results are mixed.

table describes the effects of relatively increasing degrees of the ECB's activism in inflation and real output gap stabilisation.[34]

Table 10 – Alternative monetary policy rules ($\chi_E = 5,\ 10,\ 15$)[35]

χ_E	common shock						country-specific shock					
	NC	C	F	(1,2)	(1,3)	(2,3)	NC	C	F	(1,2)	(1,3)	(2,3)
5	0.088	0.030	0.312	0.197	0.197	0.0878	12.112	7.873	7.873	11.927	7.873	10.213
	0.088	0.030	0.312	0.197	0.088	0.1967	0	0	0	3.293	0	3.293
	0.088	0.030	0.312	0.088	0.196	0.1967	12.112	7.873	7.873	10.213	7.873	12.927
	2.479	1.747	4.947	3.218	3.218	3.2184	0	0	0	4.024	0	4.024
	NC	C	F	(1,2)	(1,3)	(2,3)	NC	C	F	(1,2)	(1,3)	(2,3)
10	0.067	0.030	0.170	0.129	0.129	0.609	12.112	7.873	7.873	12.167	7.873	10.806
	0.067	0.030	0.170	0.129	0.609	0.129	0	0	0	2.954	0	2.954
	0.067	0.030	0.170	0.0609	0.129	0.129	12.112	7.873	7.8730	10.806	7.873	12.167
	2.815	1.747	5.171	3.638	3.638	3.638	0	0	0	5.606	0	5.606
	NC	C	F	(1,2)	(1,3)	(2,3)	NC	C	F	(1,2)	(1,3)	(2,3)
15	0.054	0.030	0.110	0.093	0.0930	0.047	12.112	7.873	7.873	11.644	7.873	11.235
	0.054	0.030	0.110	0.093	0.0466	0.093	0	0	0	2.731	0	2.731
	0.054	0.030	0.110	0.047	0.0930	0.093	12.112	7.873	7.873	11.235	7.873	11.644
	2.971	1.747	4.966	3.736	3.7357	3.736	0	0	0	6.213	0	6.213

Considering the case of a common shock a less active ECB in interest-rate management is always associated with governments' lower losses. The reason is simple. When economies are hit by a common shock Member States' high priority is real output stabilisation rather than inflation stabilisation and the ECB will contrast them by pursuing an opposite strategy in its setting of monetary policy. In the country-specific shock case, the ECB is inactive in symmetric regimes (NC, C, F, $(1,3)$) since the opposite policies of countries 1 and 3 compensate each other leaving no room for the ECB's activism.[36]

5 Concluding remarks

In this paper we have studied the institutional design of the co-ordination of macroeconomic stabilisation policies within the EMU and its consequences on macroeconomic outcomes and policies. We have taken into account both *ex-ante* and *ex-post* co-ordination. *Ex-ante* co-ordination is related to the institutional framework, the co-ordination procedure, and the design of policy rules within the E(M)U, whereas *ex-post* co-ordination takes place from the current state of affairs and concerns the actual policy decisions of the national governments and the ECB.

We analyse *ex-ante* co-ordination in a stylised model of the EMU as the result of an endogenous coalition formation process. From this coalition formation process, coalitions of EMU policymakers result. *Ex-post* co-ordination implies then the implementation by each coalition of its macroeconomic stabilisation policies in a non-co-operative dynamic game with the other coalitions, and subject to the constraints of the internal dynamics of the EMU economy.

Numerical simulations in a simplified three-country monetary union setting illustrate the most important aspects of our approach. In our simulations different kinds of spillovers and asymmetries

[34] High the interest-rate preference clearly imply smoothing in the central bank policy, i.e. less active.

[35] Rows indicate optimal losses of governments of countries 1, 2 and 3, and the ECB, respectively. The first submatrix regards $\chi_E = 5$, the second submatrix $\chi_E = 10$, and, finally, for $\chi_E = 15$.

[36] Recall that in this symmetric setting the ECB cannot affect countries' prices and output gaps in a differentiated manner.

have been considered since fiscal policy co-ordination is strongly connected with the externalities (fiscal spillovers) and asymmetries that are present in the economy. From the simulations some general and robust conclusions can be drawn when several symmetries (but not all) are assumed.

In the case of a common shock, fiscal co-ordination is counterproductive but full policy co-ordination is desirable. By contrast, in case of a country-specific (asymmetric) shock, fiscal co-ordination is desirable and full policy co-ordination is not associated with any extra gain in the policymakers' welfare. Our results add new features to the debate between Buti and Sapir (1998) and Beetsma *et al.* (2001) on the effects of co-ordination in the presence of shocks. Fiscal co-ordination is deficient in the case of a common shock (as suggested by Beetsma *et al.* (2001)). Nevertheless, in this situation the co-ordination among all policymakers improves the performance. The reason for this is that full co-operation reduces the tensions between the ECB and the governments in pursuing different priorities, and therefore, it reduces the costs of contrasted policies. On the contrary, fiscal co-operation increases such tensions since it increases the clash among the institutions that pursue different priorities.

When asymmetric shocks are considered, fiscal co-ordination improves the performance by internalising the traditional negative fiscal externalities (as sustained by Beetsma *et al.* (2001)) and full policy co-ordination doesn't produce further gains in the policymakers' welfare since, in this case, there are no further externalities associated with the separate management of the fiscal and monetary policies.

SGP stringency and compliance with BEPGs are significant factors influencing the outcome of the game. In the case of a common shock, they can ensure lower losses in the situation, when full co-ordination is not likely to emerge (e.g. because of exogenous political reasons). On the other hand, increased fiscal stringency is counter-productive in the case of asymmetric shocks. However, this result is obtained in the setting of perfectly symmetric countries. In such a setting changes in the ECB's policy rules prove that in the case of a common shock, full co-operation is needed to internalise externalities.

Our approach also shows that it is of crucial importance to consider how coalitions are formed (*ex-ante* co-ordination). Following the recent literature, different coalition formation mechanisms can be associated with different institutional settings where policymakers act. In fact, it can occur that, even if a co-operative solution assures for all the policymakers a lower loss than in the case of a non-co-operative solution, it does not emerge as an equilibrium of the game because of free-rider behaviour which generally leads to non-co-operative solutions according to the CNE-mechanism (even if co-operation is Pareto-superior to non-co-operation). In general, mechanisms where policymakers share more information (as the full co-operation (C), the SNE-mechanism (hierarchical), and the FCE-mechanism (farsighted)), are more likely to support co-operative solutions avoiding free-riding behaviour than the traditional CNE-mechanism, which, however, seems to be the concept that represents best the current EMU context.

The co-ordination of economic policies seems to be more difficult when the number and size of externalities become large. In this case, externalities are often associated with negative effects irrespective of the kind of shocks or fiscal spillovers considered. The *ex-post* fiscal co-ordination results are strongly connected with the size and sign of externalities (fiscal spillovers) that are present in the economy. However, results under considerable asymmetries seem to be less robust, and, therefore, they have to be interpreted with caution.

A possible extension of the analysis concerns the introduction of outside-monetary-union countries. This is a crucial issue as currently three EU Countries do not participate in the EMU and the group of EU accession countries in Central and Eastern Europe is entering on the 1^{st} of May, 2004. It will also allow, among others, to study interactions between the EU and the USA economies, since significant externalities may be present in that context.

Appendix

Reduced form of the model

Defining matrices $\eta := \begin{bmatrix} \eta_1 & 0 & ... & 0 \\ 0 & \eta_2 & ... & 0 \\ ... & ... & ... & ... \\ 0 & 0 & ... & \eta_n \end{bmatrix}$, $\gamma := \begin{bmatrix} \gamma_1 & 0 & ... & 0 \\ 0 & \gamma_2 & ... & 0 \\ ... & ... & ... & ... \\ 0 & 0 & ... & \gamma_n \end{bmatrix}$, $\rho := \begin{bmatrix} 0 & \rho_{12} & ... & \rho_{1n} \\ \rho_{21} & 0 & ... & \rho_{2n} \\ ... & ... & ... & ... \\ \rho_{n1} & \rho_{n2} & ... & 0 \end{bmatrix}$,

$\zeta := \begin{bmatrix} \zeta_1 & 0 & ... & 0 \\ 0 & \zeta_2 & ... & 0 \\ ... & ... & ... & ... \\ 0 & 0 & ... & \zeta_n \end{bmatrix}$, $\varsigma := \begin{bmatrix} 0 & \varsigma_{12} & ... & \varsigma_{1n} \\ \varsigma_{21} & 0 & ... & \varsigma_{2n} \\ ... & ... & ... & ... \\ \varsigma_{n1} & \varsigma_{n2} & ... & 0 \end{bmatrix}$, $\delta := \begin{bmatrix} -\sum_{i \in \bar{N}/1} \delta_{1i} & \delta_{12} & ... & \delta_{1n} \\ \delta_{21} & -\sum_{i \in \bar{N}/2} \delta_{2i} & ... & \delta_{2n} \\ ... & ... & ... & ... \\ \delta_{n1} & \delta_{n2} & ... & -\sum_{i \in \bar{N}/n} \delta_{ni} \end{bmatrix}$,

and $\iota_n := \begin{bmatrix} 1 \\ 1 \\ 1 \\ ... \\ 1 \end{bmatrix}$, the structural form of the model can be rewritten as:

$$\begin{cases} x(t) = -\gamma \iota_n i_E(t) + \eta f(t) + \gamma \dot{p}(t) + \delta p(t) + \rho x(t) \\ \dot{p}(t) = \zeta x(t) + \varsigma \dot{p}(t), p(0) = p_0 \end{cases}$$

Therefore, by solving the inflation equation, $\dot{p}(t) = (I - \varsigma)^{-1} \zeta x(t)$, and plugging this result in the output gap equation, we get: $x(t) = -\gamma \iota_n i_E(t) + \eta f(t) + \gamma (I - \varsigma)^{-1} \zeta x(t) + \delta p(t) + \rho x(t)$, from which we obtain the reduced form for the real output gaps:

$$x(t) = \left(I - \gamma (I - \varsigma)^{-1} \zeta - \rho \right)^{-1} (-\gamma \iota_n i_E(t) + \eta f(t) + \delta p(t))$$

and for the inflation rates:

$$\dot{p}(t) = (I - \varsigma)^{-1} \zeta \left(I - \gamma (I - \varsigma)^{-1} \zeta - \rho \right)^{-1} (-\gamma \iota_n i_E(t) + \eta f(t) + \delta p(t))$$

Rearranging:

$$\begin{bmatrix} x(t) \\ \dot{p}(t) \end{bmatrix} = L \begin{bmatrix} p(t) \\ f(t) \\ i_E(t) \end{bmatrix} = \begin{bmatrix} D & E & M \\ A & B & N \end{bmatrix} \begin{bmatrix} p(t) \\ f(t) \\ i_E(t) \end{bmatrix}$$

where:

$$\begin{aligned} D &:= \left(I - \gamma (I - \varsigma)^{-1} \zeta - \rho \right)^{-1} \delta \\ E &:= \left(I - \gamma (I - \varsigma)^{-1} \zeta - \rho \right)^{-1} \eta \\ M &:= -\left(I - \gamma (I - \varsigma)^{-1} \zeta - \rho \right)^{-1} \gamma \iota_n \\ A &:= (I - \varsigma)^{-1} \zeta \left(I - \gamma (I - \varsigma)^{-1} \zeta - \rho \right)^{-1} \delta \\ B &:= (I - \varsigma)^{-1} \zeta \left(I - \gamma (I - \varsigma)^{-1} \zeta - \rho \right)^{-1} \eta \\ N &:= -(I - \varsigma)^{-1} \zeta \left(I - \gamma (I - \varsigma)^{-1} \zeta - \rho \right)^{-1} \gamma \iota_n \end{aligned}$$

we can rewrite the reduced form equations for real outputs as:

$$\begin{cases} x_1(t) =: L_1 z(t) \\ ... \\ x_n(t) =: L_n z(t) \\ \dot{p}_1(t) =: L_{n+1} z(t) \\ ... \\ \dot{p}_n(t) =: L_{2n} z(t) \end{cases}$$

where L_i is the ith row of matrix L and $z^\intercal(t) := [p_1(t), p_2(t), ...p_n(t),\ f_1(t),\ f_2(t), ...f_n(t),\ i_E(t)]$. Thus, government i's loss function becomes:

$$J_i(t_0) = \frac{1}{2}\int_{t_0}^{\infty} \left\{\alpha_i \dot{p}_i^2(t) + \beta_i x_i^2(t) + \chi_i f_i^2(t)\right\} e^{-\theta(t-t_0)} dt =$$

$$= \frac{1}{2}\int_{t_0}^{\infty} \{z^\intercal(t)(\alpha_i L_{n+i}^\intercal L_{n+i} + \beta_i L_i^\intercal L_i + \chi_i e_{n+i}^\intercal e_{n+i}) z(t)\} e^{-\theta(t-t_0)} dt =$$

$$= \frac{1}{2}\int_{t_0}^{\infty} \{z^\intercal(t) M_i z(t)\} e^{-\theta(t-t_0)} dt, \qquad M_i \in \mathbb{R}^{(2n+1)\times(2n+1)}$$

where $e_i \in \mathbb{R}^{2n+1}$ is a vector with all entries equal to zero, except for entry i that is equal to one.

Similarly, we can rewrite the ECB's loss function as:

$$J_E(t_0) = \frac{1}{2}\int_{t_0}^{\infty} \left\{ \left(\sum_{i\in\bar{N}} \alpha_{iE}\dot{p}_i(t)\right)^2 + \left(\sum_{i\in\bar{N}} \beta_{iE} x_i(t)\right)^2 + \chi_E i_E^2(t) \right\} e^{-\theta(t-t_0)} dt =$$

$$= \frac{1}{2}\int_{t_0}^{\infty} z^\intercal(t) \left\{ \left(\sum_{i\in\bar{N}} \alpha_{iE} L_{n+i}\right)^\intercal \left(\sum_{i\in\bar{N}} \alpha_{iE} L_{n+i}\right) + \left(\sum_{i\in\bar{N}} \beta_{iE} L_i\right)^\intercal \left(\sum_{i\in\bar{N}} \beta_{iE} L_i\right) + \chi_E e_{2n+1}^\intercal e_{2n+1} \right\}$$

$$z(t) e^{-\theta(t-t_0)} dt = \frac{1}{2}\int_{t_0}^{\infty} \{z^\intercal(t) M_E z(t)\} e^{-\theta(t-t_0)} dt \qquad M_E \in \mathbb{R}^{(2n+1)\times(2n+1)}$$

The basic algorithm to derive the game solutions

Similar to the computations in Appendix A of van Aarle *et al.* (2002a) the algorithm is described by the following 5 steps.

1. Factorise matrices M_i for any country or the central bank ($i = 1, 2, ..., n, E$) as

$$M_i = \begin{pmatrix} Q_i & S_{1i} & S_{2i} & S_{3i} & ... & S_{(n-1)i} & S_{ni} & S_{Ei} \\ S_{1i}^\intercal & R_{1i} & P_{11[i]} & P_{12[i]} & ... & P_{1(n-2)[i]} & P_{1(n-1)[i]} & P_{1n[i]} \\ S_{2i}^\intercal & P_{11[i]}^\intercal & R_{2i} & P_{22[i]} & ... & P_{2(n-2)[i]} & P_{2(n-1)[i]} & P_{2n[i]} \\ S_{3i}^\intercal & P_{12[i]}^\intercal & P_{22[i]}^\intercal & R_{3i} & ... & P_{3(n-2)[i]} & P_{3(n-1)[i]} & P_{3n[i]} \\ ... & ... & ... & ... & ... & ... & ... & ... \\ S_{(n-1)i}^\intercal & P_{1(n-2)[i]}^\intercal & P_{2(n-2)[i]}^\intercal & & ... & R_{(n-1)i} & P_{(n-1)(n-1)[i]} & P_{(n-1)n[i]} \\ S_{ni}^\intercal & P_{1(n-1)[i]}^\intercal & P_{2(n-1)[i]}^\intercal & P_{3(n-1)[i]}^\intercal & ... & P_{(n-1)(n-1)[i]}^\intercal & R_{ni} & P_{nn[i]} \\ S_{Ei}^\intercal & P_{1n[i]}^\intercal & P_{2n[i]}^\intercal & P_{3n[i]}^\intercal & ... & P_{(n-1)n[i]}^\intercal & P_{nn[i]}^\intercal & R_{Ei} \end{pmatrix}$$

for $i \in \{\bar{N} \cup E\}$, where $Q_i \in \mathbb{R}^{n\times n}$, $S_{ij} \in \mathbb{R}^{n\times 1}$, while R_{ij} for $j \in \{\bar{N} \cup E\}$ and the other coefficients are scalars.

2. Compute the following matrices:

$$G := \begin{pmatrix} R_{11} & P_{11[1]} & ... & P_{1(n-1)[1]} & P_{1n[1]} \\ P^{\intercal}_{nn[2]} & R_{22} & ... & P_{2(n-1)[i]} & P_{2n[i]} \\ ... & ... & ... & ... & ... \\ P^{\intercal}_{2n[n]} & P^{\intercal}_{2(n-1)[n]} & ... & R_{nn} & P_{nn[n]} \\ P^{\intercal}_{1n[E]} & P^{\intercal}_{1(n-1)[E]} & ... & P^{\intercal}_{nn[E]} & R_{EE} \end{pmatrix}$$

$$H_1 := \begin{pmatrix} -A & 0 & 0 & 0 & ... & 0 \\ Q_1 & A^{\intercal} & 0 & 0 & ... & 0 \\ Q_2 & 0 & A^{\intercal} & 0 & ... & 0 \\ ... & ... & ... & ... & ... & ... \\ Q_n & 0 & 0 & A^{\intercal} & ... & 0 \\ Q_E & 0 & 0 & 0 & ... & A^{\intercal} \end{pmatrix}$$

$$H_2 := \begin{pmatrix} B_1 & B_2 & ... & B_n & M \\ -S_{11} & -S_{21} & ... & -S_{n1} & -S_{E1} \\ -S_{12} & -S_{22} & ... & -S_{n2} & -S_{E2} \\ ... & ... & ... & ... & ... \\ -S_{1n} & -S_{2n} & ... & -S_{nn} & -S_{En} \\ -S_{1E} & -S_{2E} & ... & -S_{nE} & -S_{EE} \end{pmatrix}$$

$$H_3 := \begin{pmatrix} S^{\intercal}_{11} & B^{\intercal}_1 & 0 & ... & 0 & 0 \\ S^{\intercal}_{22} & 0 & B^{\intercal}_2 & ... & 0 & 0 \\ ... & ... & ... & ... & ... & ... \\ S^{\intercal}_{nn} & 0 & 0 & ... & B^{\intercal}_n & 0 \\ S^{\intercal}_{EE} & 0 & 0 & ... & O & M^{\intercal} \end{pmatrix}$$

where B_i is the ith column of matrix B. Then, we can define the following matrix:

$$H \quad : \quad = H_1 + H_2 G^{-1} H_3$$

4. After computing the eigenstructure of H, take n positive eigenvalues and the corresponding eigenvectors v_i to write the following expression:[37]

$$\begin{pmatrix} X \\ Y_1 \\ Y_2 \\ ... \\ Y_n \\ Y_E \end{pmatrix} := \begin{pmatrix} v_1 & v_2 & ... & v_n \end{pmatrix} := V \in \mathbb{R}^{n(n+2)\times n}$$

from which we can derive the optimal controls:

$$\begin{pmatrix} f_1(t) \\ f_2(t) \\ ... \\ f_n(t) \\ i_E(t) \end{pmatrix} = -G^{-1} \begin{pmatrix} S^{\intercal}_{11} + B^{\intercal}_1 K_1 \\ S^{\intercal}_{22} + B^{\intercal}_2 K_2 \\ ... \\ S^{\intercal}_{nn} + B^{\intercal}_n K_n \\ S^{\intercal}_{EE} + M^{\intercal}_E K_{n+1} \end{pmatrix} p =: Fp$$

[37] If matrix H has more than n positive eigenvalues multiple equilibria arise, whereas if this matrix has less than n positive eigenvalues no equilibrium exists (for more details see Engwerda (1998)).

where $K_i := Y_i X^{-1}$ for $i \in \{\bar{N} \cup E\}$.

5. Rewrite the policymakers' cost functions[38] and the dynamics of the model as $J_i(t) = \frac{1}{2}\int_0^\infty p^\intercal \left[(I, F^\intercal)\, M_i \left(\begin{array}{c} I \\ F \end{array} \right) \right.$ dt and $\dot{p}(t) = (A + (BN)\ F)\, p(t) =: A_{CL} p(t)$, respectively. The problem is then solved by considering:

$$J_i = p_0^\intercal X_i p_0$$

where X_i solves the following Lyapunov equation (for $i \in \{\bar{N} \cup E\}$):

$$A_{CL}^\intercal X_i + X_i A_{CL} + \frac{1}{2}\,(I, F^\intercal)\, M_i \left(\begin{array}{c} I \\ F \end{array} \right) = 0$$

Co-operative solutions are achieved by using the same algorithm but considering joint losses minimisation[39].

Two algorithms for calculating coalitional equilibria

Two algorithms are presented which give two different ways how coalitions might be formed. The first one is based on Bloch's (1996) ideas and describes a sequential process how coalitions might be formed. The second is based on the idea of farsightedness and describes which coalitions can be ruled out in this situation. It does not determine what will happen but what possibly can happen. The sequential coalition formation process (computing the SNE) and the farsighted process (computing the FCE) should mimic the various cases.

The sequential coalition formation process

1. In order to determine the order of moves in the sequential game of coalition formation, fix a rule of order for the players.

2. The first player starts the game according to the rule of order by considering the question whether it is rational for her to propose a coalition. To that end she considers the worst possible outcome that can occur if she does not form a coalition, i.e.[40]:

   $$J_1^r := max_{(\{1\},\{.\})} J_1(.).$$

   If J_1^r is smaller than the cost she infers by forming whatever coalition, player 1 will propose no coalition and leaves the game. That is, the game continues with step 2. with player 1 playing non-cooperatively and player 2 starting the game.
   If there is at least one coalition form where the cost of player 1 is lower than J_1^r we assume [41] that player 1 will propose a coalition according to the following rules:

[38] For reasons of convenience, we assume that $t_0 = 0$ and θ is equal to zero. Assuming θ different from zero, the model could easily be solved following the procedure used in this paper after a simple transformation of variables, i.e. transforming $x(t)$ into $e^{-\frac{1}{2}\theta t}x(t)$ and substituting A by $A - \frac{1}{2}\theta I$ where $I \in \mathbb{R}^{n\times n}$ is a diagonal matrix with ones on the main diagonal (see Engwerda *et al.* (1999), p.263, for further details).

[39] For more details see e.g.: van Aarle *et al.* (2002b) or Engwerda *et al.* (2002, Appendix B).

[40] Notation: ({1} {.}) denotes the case in which player 1 plays non-coperatively, whereas other players may form any coalitions (but may also play non-co-operatively).

[41] Note that we assume here that player 1 is risk averse, i.e. it might happen that e.g. in the non-cooperative case her cost is lower than the minimal cost she can incur by forming any coalition. However, since she is not able to enforce the non-cooperative solution, we choose to select this definition of rationality.

i) Select that coalition where her cost is as small as possible.

ii) If there is more than one coalition satisfying i), choose that coalition containing the most important players.

iii) If there is more than one coalition satisfying ii), select that coalition which contains the highest number of players.

Rules ii) and iii) say that e.g. the coalition {1,2,3} is preferred above the coalitions {1,2} and {1,2,4}.
Next proceed with step 3.

3. Verify whether all players in the coalition agree on this coalition according to the rule of order. That is: player i agrees on this coalition if her cost in this coalition is smaller or equal than both the cost she incurs by joining any other feasible coalition and the worst possible outcome if she does not join any feasible coalition. The set of feasible coalitions is determined by the history of the game. That is, the set of feasible coalitions, FC, contains only those coalitions which are still realisable given the history of the game. More formally, verify whether:

$$J_i(coalition) \leq \min\{\min_{(\{i,..\},\{..\})\in FC} J_i(.), \max_{(\{i\},\{..\})\in FC} J_i(.)\}.$$

holds for all players in the foreseen coalition.

4. If all players agree on the coalition, the coalition is formed and the players leave the game. The coalition process repeats with the remaining players from step 2. on.
If not all players agree, the first player who disagrees may come up with a coalition proposal if she did not have this opportunity for this set of feasible coalitions before. In that case the coalition process repeats from step 2. on. Otherwise, a cycle has occurred, and the coalition formation process would repeat itself *ad infinitum*. We assume that in that case all players that are still involved in the formation process all play non-co-operatively.

Examples:

1. Table 4
1. Order: 1,2,3,ECB
2. Player 1 may propose:
$J_1^r = \max\{5.1464 ; 3.9647\} = 5.1464$
Player 1 proposes the fiscal coalition F as:
$FC(1) = 3.3142 = \min\{3.4654; 3.3142; 4.2673; 11.5036\} < J_1^r = 0.5.1464$
3. Reaction of other players to the proposal of the Player 1:
Player 2 rejects as:
$FC(2) = 14.5786 > \min\{\min\{14.0739, 18.2389, 18.2389\}, \max\{22.0439; 17.5804\}\}$
$= \min\{14.0739; 22.0439\} = 14.0739$
4. Player 2 may propose:
$J_2^r = \max\{22.0439; 17.5804\} = 22.0439;$
Player 2 proposes the full coalition F as:
$F(2) = 14.0739 < \min\{18.2389\} < J_1^r = 22.0439;$
5. Reaction of other players to the proposal of the Player 2:
Player 1 accepts as:
$C(1) = 3.4654 < \min\{\min\{4.2673; 11.5036\} , \max\{5.1464, 3.9647\}\}$
$= \min\{4.2673; 5.1464\} = 4.2673$

Player 3 accepts as:
$C(3) = 3.4654 < \min\{\min\{11.5036;\ 4.2673\}\ ,\ \max\{5.1464;\ 3.9647\}\}$
$= \min\ \{4.2673;\ 5.1464\} = 4.2673.$
Player 4 accepts as:
$C(4) = 0.1942 < \min\{\max\{\ 0.2155;\ 0.3398;\ 0.9281;\ 1.9266;\ 0.9281\}$
$= \min\ \{0.2155\} = 0.2155.$
Therefore, $SNE = C$.

2. Table 6
1. Order: 1,2,3,ECB
2. Player 1 may propose:
$J_1^r = \max\{0.8495\ ;\ 0.5601\} = 0.8495$
Player 1 proposes the full coalition C as:
$C(1) = 0.2595 = \min\{0.2595;\ 3.2141;\ 1.5506;\ 1.1005\} < J_1^r = 0.8495$
3. Reaction of other players to the proposal of the Player 1:
Player 2 accepts as:
$C(2) = 0.0211 < \min\{\min\{0.9217;\ 0.3791;\ 0.9392\},\ \max\{0.2324;\ 0.2611\}\}$
$= \min\ \{0.3791;\ 0.2611\} = 0.2611$
Player 3 accepts as:
$C(3) = 0.4693 < \min\{\min\{1.6742;\ 0.9135;\ 1.4012\}\ ,\ \max\{0.9284;\ 0.9259\}\}$
$= \min\ \{0.9135;\ 0.9284\} = 0.9135$
Player 4 accepts as:
$C(4) = 1.0527 < \min\{\max\{1.3575;\ 4.7740;\ 2.1305\ ;\ 2.1248;\ 1.6007\}$
$= \min\ \{4.7740\} = 4.7740$
Therefore, $SNE = C$.

3. Table 7
1. Choose as the rule of order, 1,2,3,ECB.
2. Player 1 may propose.
$J_1^r = \max_{(\{1\},\{..\})} J_1(.) = \max\{0.4788, 0.3933\} = 0.4788.$
$0.269 = \min_{(\{1,..\},\{..\})} J_1(.) < J_1^r$. So, player 1 chooses the full coalition C.
3. Player 2 accepts.
Player 3 does not accept as $0.5124 > \min\{\min\{0.5841, 0.4395, 0.5822\}, \max\{0.4776, 0.5137\}\}$
$= 0.4395$.
2. player 3 may propose.
$J_3^r = \max\{0.4776, 0.4395\} = 0.4776.$
$J_3^r < \min\{0.5124, 0.5841, 0.5137, 0.5822\}$. So, player 3 prefers to play non-co-operatively.
2. player 1 may propose.
Since player 3 plays non-cooperatively, the set of feasible coalitions contains only (1,2).
As $0.4788 < 0.6254$ player 1 chooses a non-co-operative mode of play too.
2. player 2 may propose.
Since both player 1 and player 2 play non-co-operatively, the set of feasible coalitions is NC.
So, player 3 is forced to play non-co-operatively too as well as the ECB.
Hence, NC results.

4. Table 8
1) The selected order: 1,2,3,ECB
2) Player 1 may propose:
$J_1^r = \max\ \{2.9561;\ 3.0079\} = 3.0079$
Player 1 finds that coalition $C = 0.2587 = \min\{0.2587;\ 17.0234;\ 8.2460;\ 4.2768\}$
Since $C < J_1^r$ Player 1 proposes C.

3) Player 2 accepts as:
$C(2) = 0.0318 < \min\{\min\{6.0395; 2.3099; 2.1750\}, \max\{1.6041; 2.4814\}\}$
$= \min\{2.1750; 2.4814\} = 2.1750$
4) Player 3:
$C(3) = 0.5870 > \min = \{\min\{4.7338; 0.9831; 2.1569\}, \max\{0.2236; 0.1954\}\}$
$= \min\{0.9831; 0.2236\} = 0.2236 = NC(3)$
Players 3 rejects.
5) Player 3 proposes:
$J_{r3} = \max\{0.2236; 0.1954\} = 0.2236;$
$NC(3) = 0.2236 < \min\{4.7338; 0.9831; 2.1569\} = 0.9831$
Player 3 decides to play non-co-operatively.
6) Player 1 may propose:
The only feasible coalition for P1 is now only (1,2).
Since $NC(1) <$ (1,2)(1) Player 1 decides to play non-cooperatively.
7) Since Players 1 and 3 play non-co-operatively there are no other possible coalitions.
Hence, SNE = NC.

□

The farsighted coalition process

1. Make a preference list for each of the individual players, i.e. for each player determine which coalition yields the lowest cost, the one-but lowest cost etc.

2. Determine for each player i the minimum cost it can enforce by playing non-cooperatively, i.e. determine for each i
$$J_i^r := \max_{(\{i\},\{..\})} J_i(.).$$

3. Determine for each player i all coalitions for which $J_i(.) \leq J_i^r$. Denote this set of feasible coalitions for each player i by $FC(i)$.

4. Determine all coalitions which are in the intersection of all sets of feasible coalitions. Call this set the Rational Feasible Coalitions set (RFC).

5. Drop within the set RFC those coalitions which are Pareto dominated by another coalition. That is, if e.g. both coalitions F and C belong to RFC but C is preferred by every player above F, the coalition F is dropped from the set RFC.

6. Look for coalitions within this set that satisfy some additional properties as internal and external stability, or exogenous factors that support certain equilibria.

Examples:

1. Table 4
1. Preference list:
Player 1: $F \succeq C \succeq (2,3) \succeq (1,2) \succeq NC \succeq (1,3)$
Player 2: $C \succeq F \succeq (1,3) \succeq (1,2) = (2,3) \succeq NC$
Player 3: $F \succeq C \succeq (1,2) \succeq (2,3) \succeq NC \succeq (1,3)$
ECB: $C \succeq NC \succeq F \succeq (1,2) = (2,3) \succeq (1,3)$
2. Maximum cost of non-cooperative playing:
$J_1^r = \max\{5.1464 ; 3.9647\} = 5.1464;$

$J_2^r = \max\{22.0439;\ 17.5804\} = 22.0439;$
$J_3^r = \max\{5.1464\ ;\ 3.9647\} = 5.1464;$
$J_4^r = \max\{\ 0.2155,\ 0.3398;\ \dots\} = 1.9266.$
3. FC for each player:
$FC(1) = \{F, C, (2,3), (1,2)\}$
$FC(2) = \{C, F, (1,3), (1,2), (2,3)\}$
$FC(3) = \{F, C, (2,3), (1,2)\}$
$FC(4) = \{C, NC, (2,3), (1,3), (1,2), F\}$
5. $RFC = \{C, F\}$
6. The final coalitional outcome - C or F - depends on other factors that are included into the algorithm - e.g. exogenous political factors as the existence of a transfer system. Since, the combined loss of all the players is lower in the full coalition than in the fiscal coalition, the C-regime would be chosen more likely in that case.
Hence, FCE $= C, F$.

2. Table 6

1. Preference list:
Player 1: $C \succeq (2,3) \succeq NC \succeq (1,3) \succeq (1,2) \succeq F$
Player 2: $C \succeq NC \succeq (1,3) \succeq (1,2) \succeq F \succeq (2,3)$
Player 3: $C \succeq (1,3) \succeq (1,2) \succeq NC \succeq (2,3) \succeq F$
ECB: $C \succeq NC \succeq (2,3) \succeq (1,3) \succeq (1,2) \succeq F$
2. Maximum cost of non-cooperative playing:
$J_1^r = \max\{0.8495\ ;\ 0.5601\} = 0.8495$
$J_2^r = \max\{0.2324\ ;\ 0.2611\} = 0.2324$
$J_3^r = \max\{0.9284\ ;\ 0.9259\} = 0.9284$
$J_4^r = \max\{\ 1.3575;\ 4.7440;\ \dots\} = 4.7440$
3. Feasible coalitions for each player:
$FC(1) = \{C, (2,3), NC\}$
$FC(2) = \{C, NC\}$
$FC(3) = \{C, (1,3), (1,2), NC\}$
$FC(4) = \{C, NC, (2,3), (1,3), (1,2), F\}$
5. $RFC = \{C, F, \}$
6.NC is *Pareto-dominated* by C as all $C(i) \succ NC(i)$
Hence, FCE $= C$.

3. Table 7
1. The preference list is as follows:
1: $C \succeq (1,3) \succeq (2,3) \succeq NC \succeq F \succeq (1,2)$
2: $C \succeq (1,3) \succeq NC \succeq F \succeq (1,2) \succeq (2,3)$
3: $(1,2) \succeq NC \succeq C \succeq (1,3) \succeq (2,3) \succeq F$
ECB: $C \succeq (2,3) \succeq NC \succeq (1,3) \succeq (1,2) \succeq F$
2. $J_1^r = \max\{0.4788, 0.3933\} = 0.4788.$
$J_2^r = \max\{0.0627, 0.0513\} = 0.0627.$
$J_3^r = \max\{0.4776, 0.4395\} = 0.4776.$
$J_4^r = \max\{1.1638, 1.4047, 1.3364, 1.1756, 1.1383\} = 1.4047$
3. Feasible coalitions for each player:
$FC(1) = \{C, (1,3), (2,3), NC\}.$
$FC(2) = \{C, (1,3), NC\}.$
$FC(3) = \{(1,2), NC\}.$
$FC(4) = \{C, (1,3), (2,3), NC, (1,2), F\}.$
4. $RFC = \{NC\}.$

So, the only potential equilibrium is NC.

4. Table 8

1. Preference list:
Player 1: $C \succeq NC \succeq (2,3) \succeq (1,3) \succeq (1,2) \succeq F$
Player 2: $C \succeq NC \succeq (2,3) \succeq (1,2) \succeq (1,3) \succeq F$
Player 3: $(1,2) \succeq NC \succeq C \succeq (1,3) \succeq (2,3) \succeq F$
ECB: $C \succeq NC \succeq (2,3) \succeq (1,3) \succeq (1,2) \succeq F$
2. Maximum cost of non-cooperative playing:
$J_1^r = \max\{2.9561 \ ; \ 3.0079\} = 3.0079$
$J_2^r = \max\{1.6041 \ ; \ 2.4818\} = 2.4818$
$J_3^r = \max\{0.2236 \ ; \ 0.1954\} = 0.2236$
$J_4^r = \max\{ \ 3.3302 \ ; \ 21.7730, \ldots . \ \} = 21.7730$
3. Feasible coalitions for each player:
$FC(1) = \{C, NC, (2,3)\}$
$FC(2) = \{C, NC, (2,3), (1,2), (1,3)\}$
$FC(3) = \{(1,2), NC\}$
$FC(4) = \{C, NC, (2,3), (1,3), (1,2), F\}$
4. $RFC = \{NC\}$
Hence, FCE = NC.

□

References

Aarle, B. van, J. Engwerda and J. Plasmans (2002a), "Monetary and fiscal policy interaction in the EMU: A dynamic game approach", *Annals of Operations Research*, vol. 109, pp. 229-264.

Aarle, B. van, G. Di Bartolomeo, J. Engwerda and J. Plasmans (2002b), "Coalitions and dynamic interactions between fiscal and monetary authorities in the EMU", *Ifo Studien*, vol. 48, No. 2, pp. 207-229.

Acocella,. N. and G. Di Bartolomeo (2001), "Wage and public expenditure setting in a monetary union", *Working Paper* No. 42., Department of Public Economics, University of Rome 'La Sapienza'.

Agell, J., L. Calmfors and G. Jonsson (1996), "Fiscal policy when monetary policy is tied to the mast", *European Economic Review*, vol. 40: 1413-1440.

d'Aspremont, C.A., A. Jacquemin, J.J. Gabszewicz and J. Weymark (1983) "On the stability of collusive price leadership", *Canadian Journal of Economics*, vol. 16, pp. 17-25.

Beetsma, R.M.W.J. and Bovenberg A.L. (1998), "Monetary union without fiscal coordination may discipline policymakers?", *Journal of International Economics*, vol. 45, pp. 239-258.

Beetsma, R.M.W.J., X. Debrun and F. Klaassen (2001), "Is fiscal policy coordination in EMU desirable?", CESIfo *Working Paper* No. 599, Center for Economic Studies and Ifo Institute for Economic Research, Munich.

Bloch, F. (1996), "Sequential formation of coalitions in games with externalities and fixed payoff division", *Games and Economic Behavior*, vol. 14, pp. 90-123.

Buti, M. and A. Sapir (Eds.) (1998), *Economic Policy in EMU: A Study by the European Commission Services,* Oxford University Press, Oxford.

CESifo (2002), *Report on the European Economy 2002*, Center for Economic Studies and Ifo Institute for Economic Research, Munich.

Chwe, M.S. (1994), "Farsighted coalitional stability", *Journal of Economic Theory*, vol. 54, pp. 299-325.

Clarida, R., J. Galí and M. Gertler (1999), "The Science of Monetary Policy: A New Keynesian Perspective", *Journal of Economic Literature*, vol. 37, pp. 1661-1707.

Debrun, X. (2000) "Fiscal rules in a monetary union: a short run analysis", *Open Economies Review*, vol. 11, pp. 323-358.

Di Bartolomeo, G., J.C. Engwerda and J.E.J. Plasmans (2002a), "Stabilization policies in a monetary union: Two-stage games of endogenous fiscal coalition formation", *Working Paper.*

Di Bartolomeo, G., J.C. Engwerda, J.E.J. Plasmans and B. van Aarle (2002b), "Staying together or breaking apart: Policy-makers' endogenous coalitions formation in the European Economic and Monetary Union", *Working Paper* No. 13, Faculty of Applied Economics UFSIA-RUCA, University of Antwerp and CESifo *Working Paper* No. 748, Center for Economic Studies and Ifo Institute for Economic Research, Munich.

Di Bartolomeo, B. Merlevede, J. Plasmans and B. van Aarle (2003), "Monetary Policy regimes in the New Keynesian Framework: Results for Accession Countries", mimeo, University of Antwerp.

DiNardo, J. and M.P. Moore (1999), "The Phillips Curve is Back? Using Panel Data to Analyze the Relationship Between Unemployment and Inflation in an Open Economy", National Bureau of Economic Research *Working Paper* No. 7328.

ECB (1999), "The stability-oriented monetary policy in the Eurosystem", *Monthly Bulletin* (January), Frankfurt, ECB.

Ecchia, G. and M. Mariotti (1998), "Coalition formation in international environmental agreements and the role of institutions", *European Economic Review*, vol. 42, pp. 573-582.

Engwerda, J. (1998), "Computational aspects of the open-loop Nash equilibrium in linear quadratic games", *Journal of Economic Dynamics and Control*, vol. 22, pp. 1487-1506.

Engwerda, J., B. van Aarle and J. Plasmans (1999), "The (in)finite horizon open-loop Nash LQ game: An application to the EMU", *Annals of Operations Research*, vol. 88, pp. 251-273.

Engwerda, J., B. van Aarle and J. Plasmans (2002), "Cooperative and non-cooperative fiscal stabilisation policies in the EMU", *Journal of Economic Dynamics and Control*, vol. 26, pp. 451-481.

Favero, C., X. Freixas, T. Pesson and C. Wyplosz (2000), "One money many countries, monitoring the European Central Bank 2", London, Center for Economic Policy Research.

Issing, O. (1999), "The Eurosystem: transparent and accountable, or Willem in Euroland", *Journal of Common Market Studies*, vol.. 37, pp. 503-521.

Jensen, H. (1996), "The advantage of international fiscal cooperation under alternative monetary regimes", *European Journal of Political Economy,* vol. 12, pp. 485-504.

Kehoe, T. (1988), "Policy coordination among benevolent governments may be undesirable", *Review of Economic Studies*, vol. 56, pp. 289-296.

Mariotti, M. (1998), "A model of agreements in a strategic form games", *Journal of Economic Theory*, vol. 73, pp. 128-139.

Monteforte, L. and S. Siviero, "Aggreate vs. Disaggregate Euro-Area Maco-Modelling", mimeo, Bank of Italy.

Monfort, A., J.P. Renne, R. Ruffer and G. Vitale (2002), "Is Economic Activity in the G7 Synchronised? Common Schock vs. Spillovers Effects", mimeo.

Levine, P. and A. Brociner (1994), "Fiscal policy coordination and EMU", *Journal of Economic Dynamics and Control*, vol. 18, pp. 699-729.

Onorante, L. (2002), "The interaction of fiscal policies in the Euro area: how much pressure on the ECB?", Cambridge, Cambridge University Press, forthcoming.

Ray, D. and R. Vohra (1999). "A theory of endogenous coalition structures", *Games and Economic Behavior*, vol. 26, pp. 286-336.

Razin, A. and C.W. Yuen (2001), "The 'New Keynesian' Phillips curve: Closed economy vs. open economies", National Bureau of Economic Research *Working Paper* No. 8313.

Rogoff, K. (1985), "Can international monetary cooperation be counterproductive?", *Journal of International Economics*, vol. 18, pp. 199-217.

Uhlig, H.(2002), "One money, but many fiscal policies in Europe: what are the consequences?", *CentER Discussion Paper* No. 32.