COALITIONAL BEHAVIOR IN AN OPEN-LOOP LQ-DIFFERENTIAL GAME FOR THE EMU

B. van Aarle * G. Di Bartolomeo ** J. Engwerda * J. Plasmans ******

* *University of Leuven and University of Nijmegen*
** *University of Antwerp and University of Rome La Sapienza*
*** *Tilburg University*
**** *University of Antwerp and Tilburg University*

Abstract: The interaction of monetary and fiscal policies is a crucial issue in a highly integrated economic area as the EU. In this paper we study policy cooperation. In particular, we focus on how coalitions among policy-makers are formed and what are their effects on the stabilization of output and price.

Keywords: Macroeconomic stabilization, EMU, coalition formation, linear quadratic differential games

1. INTRODUCTION

It is expected that the introduction of the EMU, which implies a common monetary policy and restrictions on fiscal policy at the national level, increases the need for macroeconomic policy cooperation due to the various interactions, spillovers and externalities from national macroeconomic policies. To study the effects of policy cooperation we compare the impact of three alternative policy regimes in a stylized dynamic model of the EMU: (i) non-cooperative monetary and fiscal policies, (ii) partial cooperation, and (iii) full cooperation both in symmetric and asymmetric settings where countries differ in structural characteristics, policy preferences and/or bargaining power. We assume that the EMU consists of two (blocks of) asymmetric countries where the European Central Bank (ECB) is responsible for monetary policy and where its primary goal is to achieve price stability and to promote economic stabilization (preferably along a growth path) as long as price stability is not endangered. The governments of the two (blocks of) countries are assumed to determine fiscal policy in their countries such that output is stabilized under the restriction that no excessive deficits occur, and that prices do not fluctuate too much. The goals of each party (player) that is involved are formalized in a welfare function that she likes to optimize. This setting naturally leads to model the policy coordination problem as a dynamic game in which each player is looking for that strategy which optimizes her welfare.

Based on a model developed by Neck and Dockner (1995), Engwerda *et al.* (2001) have studied the effects of cooperative and non-cooperative macroeconomic policies. They analyze macroeconomic stabilization among three players in a dynamic model of the EMU. Cooperation has also been analyzed in Hughes Hallett and Ma (1996), Demertzis *et al.* (1999), Engwerda *et al.* (2001), and van Aarle *et al.* (2001). Hughes Hallett and Ma (1996) find that asymmetries tend to increase the scope for policy cooperation. In their paper the asymmetric cases display for all players larger gains from cooperation than in the symmetric base scenario. This last result is only partially confirmed in van Aarle *et al.* (2001) in the following sense. The Hughes Hallett and Ma's (1996) result is confirmed except for the case of asymmetric bargaining powers among players, where it was observed that the stronger the asymmetry in the bargaining powers is, the less probable policy-cooperation and coalitions are, since policies will be biased towards the needs of the stronger player(s) and the smaller players are less likely to stay in such 'asymmetric' coalitions. Demertzis *et al.* (1999) illustrate that, at least when (output or inflation) shocks are symmetric, national governments make the largest gains by imposing strong forms of accountability, e.g. inflation targeting. However, it is observed that these gains come at the expense of the ECB, and those whose preferences are aligned with the ECB. Accountability can therefore go too far, but some degree of accountability is always desirable for everyone. This result emphasizes the obvious attraction of allowing a fiscal coalition to take responsibility for the design of monetary policy, which illustrates the weakness of an independent ECB.

A first analysis of the partial coalition model presented in this paper was already performed by van Aarle *et al.* (2001). The sustainability of a certain type of coalition and its implications for the optimal strategies and the resulting macroeconomic adjustment were seen to be highly sensitive to the initial settings of the preferences and the structural model parameters. They found that cooperation is often efficient for the fiscal players. On the other hand, it was shown that full cooperation of all three players does not always induce a Pareto improvement for the ECB, and that a coalition between governments often implies a considerable loss for the ECB compared to the non-cooperative and full cooperative cases. In the cases that the ECB cooperates with one government against the other, it often gains a considerable Pareto-improvement but both governments lose. Therefore, in the experiments made in that paper a kind of dualism arises between the cooperative solutions and the non-cooperative one.

In this paper policy-makers facing a stabilization problem play a two-stage game. In the first stage – the coalition game – they decide non-cooperatively whether or not to sign an agreement about policy-coordination after that an asymmetric price shock has been observed. In the second stage – the stabilization game – they (generally) play the non-cooperative Nash game, where the policy-makers who sign the agreement play as a single player sharing a common loss function. This paper is organized as follows. The next section outlines the model, while section 3 derives the properties of the symmetric solution of the game. Section 4 discusses the different equilibria used for determining the emerging coalitions. Section 5 solves the game numerically and section 6 concludes.

2. A SIMPLE EMU DYNAMIC MODEL

The economy is represented by a dynamic two-country EMU model as in van Aarle *et al.* (2001). The model is expressed in deviations from the long term equilibrium (balanced growth path) that has been normalized to zero, for simplicity. The model consists of the following equations:

$$\begin{aligned}
y_1(t) &= \delta_1 s(t) - \gamma_1 r_1(t) + \rho_1 y_2(t) + \eta_1 f_1(t)\\
\dot{p}_1(t) &= \xi_1 y_1(t)\\
y_2(t) &= -\delta_2 s(t) - \gamma_2 r_2(t) + \rho_2 y_1(t) + \eta_2 f_2(t)\\
\dot{p}_2(t) &= \xi_2 y_2(t)\\
s(t) &= p_2(t) - p_1(t)
\end{aligned}$$

where y_j denotes real output in country j, s competitiveness of country 2 vis-à-vis country 1, $r_j := i_E(t) - \dot{p}_j(t)$ the real interest rate, p_j the price level and f_j the real fiscal deficit in country $j \in \{1,2\}$, and i_E the common nominal interest rate. All variables are in logarithms, except for the interest rate that is in percentages. A dot above a variable denotes its time derivative.

The above equations describe the structure of the two economies where the policy-makers are assumed to have intertemporal objective functions:

$$L^i(t_0) = \frac{1}{2}\int_{t_0}^{\infty} \{\alpha_i \dot{p}_i^2(t) + \beta_i y_i^2(t) + \chi_i f_i^2(t)\}\varphi$$

for $i \in \{1,2\}$, where $\varphi := e^{-\theta(t-t_0)}dt$, and

$$L^E(t_0) = \frac{1}{2}\int_{t_0}^{\infty} \left\{\dot{P}^2 + Y^2 + \chi_E i_E^2(t)\right\}\varphi$$

where $\dot{P} := \sum_{i=1}^{2} \alpha_{iE}\dot{p}_i(t)$, $Y := \sum_{i=1}^{2} \beta_{iE} y_i(t)$.

We assume that the fiscal authorities control their fiscal policy instrument such as to minimize a quadratic loss function which features domestic inflation, output and fiscal deficit. Preference for a low fiscal deficit reflects the costs of excessive deficits. In both cases the total cost to be minimized is a discounted sum of the costs incurred at each period, with θ denoting the discount rate.

From the structural form of the model, we derive the reduced form by solving for $y_1(t)$, $y_2(t)$ and $\dot{s}(t)$:

$$\begin{aligned}
y_1(t) &= b_1 s(t) - c_1 i_E(t) + a_1 f_1(t) + \frac{\rho_1}{k_1} a_2 f_2(t)\\
y_2(t) &= -b_2 s(t) - c_2 i_E(t) + \frac{\rho_2}{k_2} a_1 f_1(t) + a_2 f_2(t)
\end{aligned}$$

where $k_i := 1 - \gamma_i \xi_i$, $a_i := \frac{\eta_i k_j}{k_i k_j - \rho_i \rho_j}$, $b_i := \frac{\delta_i k_j - \rho_i \delta_j}{k_i k_j - \rho_i \rho_j}$, $c_i := \frac{\gamma_i k_j + \rho_i \gamma_j}{k_i k_j - \rho_i \rho_j}$, and

$$\dot{s}(t) = \phi_4 s(t) - \phi_1 f_1(t) + \phi_2 f_2(t) + \phi_3 i_E(t)$$

where $s(0) =: s_0$, $\phi_i := (\xi_i - \xi_j \frac{\rho_j}{k_j}) a_i$, $\phi_3 := \xi_1 c_1 - \xi_2 c_2$ and $\phi_4 := -(\xi_2 b_2 + \xi_1 b_1)$ for $i, j \in \{1, 2\}$ and $i \neq j$. The last equation denotes the dynamics of the model: it is a first-order linear differential equation. The initial value of the state variable, s_0, measures any initial disequilibrium in competitiveness. Such an initial disequilibrium in competitiveness could be the result of differences in fiscal policies in the past or some initial supply side disturbance in one country.

Defining $x^T(t) := [s(t),\ f_1(t),\ f_2(t),\ i_E(t)]$, the objectives of the policy-makers can be written as: [1]

$$J^i(t_0) = \frac{1}{2} d_i \int_{t_0}^{\infty} \{x^T(t) M_i x(t)\} \varphi \quad i \in \{1, 2\}$$

$$J^E(t_0) = \frac{1}{2} \int_{t_0}^{\infty} \{x^T(t) M_E x(t)\} \varphi$$

where $M_i := m_i^T m_i + \frac{\chi_i}{d_i} e^T_{(i+1)} e_{(i+1)}$ for $(i = \{1, 2\})$ and $M_E := d_{1E} m_1^T m_1 + d_{2E} m_2^T m_2 + d_{3E} m_1^T m_2 + 2 d_{3E} m_2^T m_1 + \chi_E e_4^T e_4$ with $d_i := \alpha_i \xi_i^2 + \beta_i$, $d_{iE} := \alpha_{iE}^2 \xi_i^2 + \beta_{iE}^2$ for $(i = \{1, 2\})$, and $d_{3E} := \alpha_{1E} \alpha_{2E} \xi_1 \xi_2 + \beta_{1E} \beta_{2E}$; $e_l \in \mathbb{R}^4$ is defined as the unit row vector with the *l-th* entry equal to 1 whereas the remaining values are equal to zero; $m_1 := \left[b_1, a_1, \frac{\rho_1}{k_1} a_2, -c_1\right]$ and $m_2 := \left[b_2, \frac{\rho_2}{k_2} a_2, a_2, -c_2\right]$. Henceforth, for reasons of convenience, we assume that $t_0 = 0$ and $\theta = 0$ (if θ differs from zero, the model could easily be solved following the same procedure used in this paper after a simple transformation of variables [2]).

For each coalition Ω that the players can form, the problem that policy-makers face in the stabilization game can be summarized as the minimization of the following loss functions:

$$J^C = \frac{1}{2} \int_0^{\infty} \left\{ \sum_{i \in \Omega} \tau_i d_i x^T(t) M_i x(t) \right\} dt$$

$$J^S = \frac{1}{2} d_i \int_0^{\infty} \{x^T(t) M_i x(t)\} dt \qquad \forall i \notin \Omega$$

with respect to the reduced form of the model (J^C for the cooperative (where the τ_i sum to 1) and J^S for each of the non-cooperative policy-makers with $d_E := 1$).

[1] For detailed derivations see van Aarle *et al.* (2001).

[2] That is, transforming $x(t)$ into $e^{-\frac{1}{2}\theta t} x(t)$ and substituting ϕ_4 by $\phi_4 - \frac{1}{2}\theta$ (see Engwerda *et al.* (2001) for further details).

The solution of that problem consists of the following optimal controls:

$$\begin{pmatrix} f_1(t) \\ f_2(t) \\ i_E(t) \end{pmatrix} =: \Psi_{(\Omega)} s(t)$$

Then, using the above optimal controls we obtain the corresponding optimal players' optimal costs:

$$J^i_{(\Omega)} = \frac{1}{2} d_i (1\ \Psi^T_{(\Omega)}) M_i \begin{pmatrix} 1 \\ \Psi_{(\Omega)} \end{pmatrix} \frac{s_0^2}{2 \psi_{(\Omega)}}$$

for $i = \{1, 2, E\}$. The vector $\Psi_{(\Omega)}$ and the (eigen)value $\psi_{(\Omega)}$ are computed according to the algorithm reported in the appendix of van Aarle *et al.* (2001).

3. THE SYMMETRIC SOLUTION

In this section we consider the model described in the previous section under the assumption of symmetry of countries 1 and 2. In that case one can obtain theoretical results. Details on calculations can be found in the extended version of this paper. The outcomes of this analysis are not only interesting on their own, but may also be helpful in analyzing the properties of the asymmetric model. We make the following assumptions with respect to the various parameters: $\alpha_i =: \alpha$, $\alpha_{iE} =: \alpha_E$, $\beta_i =: \beta$, $\beta_{iE} =: \beta_E$, $\chi_i =: \chi$, $\xi_i =: \xi$, $\gamma_i =: \gamma$, $\rho_i =: \rho$, $\delta_i =: \delta$ and $\eta_i =: \eta$ for $i \in \{1, 2\}$. Furthermore we introduce the following parameters for notational convenience: $a := a_i$, $e := \frac{\rho_1}{k_1} a_2 = \frac{\rho_2}{k_2} a_1$, $c := c_i$, $b := b_i$, $d := d_i$, $d_N := \tau + (1 - 2\tau) \frac{\alpha_E^2 \xi_1^2 + \beta_E^2}{d}$, where τ is some number between 0 and $\frac{1}{2}$, $g := \frac{\chi_i}{d}$, and $g_E := \frac{\chi_E}{\alpha_E^2 \xi_1^2 + \beta_E^2}$ for $i \in \{1, 2\}$. Then, the dynamics are given by the state equation

$$\dot{s} = \phi_4 s - \phi_1 f_1 + \phi_1 f_2;\ s(0) = s_0$$

and the performance criteria are:

$$J^i = \frac{1}{2} d_i \int_0^{\infty} \{x^T(t) M_i x(t)\} dt \ i = \{1, 2\}$$

$$J^E = \frac{\alpha_E^2 \xi^2 + \beta_E^2}{2} \int_0^{\infty} \{x^T(t) M_i x(t)\} dt$$

with

$$M_1 := \begin{pmatrix} b^2 & ab & be & -bc \\ ab & a^2 + g & ae & -ac \\ be & ae & e^2 & -ce \\ -bc & -ac & -ce & c^2 \end{pmatrix}$$

$$M_2 := \begin{pmatrix} b^2 & -be & -ab & bc \\ -be & e^2 & ae & -ce \\ -ab & ae & a^2+g & -ac \\ bc & -ce & -ac & c^2 \end{pmatrix}$$

$$M_E := \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & (a+e)^2 & (a+e)^2 & -2c(a+e) \\ 0 & (a+e)^2 & (a+e)^2 & -2c(a+e) \\ 0 & -2c(a+e) & -2c(a+e & 4c^2+g_E \end{pmatrix}$$

For the cooperative case we assume that the bargaining power coefficients satisfy $\tau_1 = \tau_2 =: \tau$ and $\tau_3 = 1 - 2\tau$, where $0 \leq \tau \leq \frac{1}{2}$. Then the various equilibrium strategies for the non-cooperative (i.e. NC), the cooperative (i.e. C) and the fiscal coalition (i.e. $(1,2)$) cases are given respectively by:

$$\begin{pmatrix} f_1(t) \\ f_2(t) \\ i_E(t) \end{pmatrix} = \begin{pmatrix} 1 \\ -1 \\ 0 \end{pmatrix} p_i s(t)$$

for $i \in \{NC, C, (1,2)\}$, and the corresponding cost for the players is:

$$J^1 = J^2 = \frac{1}{4}\frac{d}{\psi_i}\{(b + p_i(a-e))^2 + p_i^2 g\} s^2(0)$$
$$J^E = 0$$

for $i \in \{NC, C, (1,2)\}$.

Table 1 describes u_i, p_i and ψ for $i \in \{NC, C, (1,2)\}$.

Table 1 - u, p and ψ values

$i =$	NC	C	(1,2)
u_i	$a(a-e)g$	$\tau[g+(a-e)^2]$	$g+(a-e)^2$
p_i	$\frac{\phi_1 K_{NC} - ab}{u_{NC}}$	$\frac{\phi_1 K_C - \tau b(a-e)}{u_C}$	$\frac{2\phi_1 K_{(1,2)} - b(a-e)}{u_{(1,2)}}$
ψ_i^2	$(\phi_4 - 2\phi_1 p_c)^2$	$\frac{g\phi_4}{g+(a+e)^2}$	$\frac{g\phi_4^2}{u_{(1,2)}}$

where, the following notations are introduced: $u := 2\phi_4 u_{NC} + b\phi_1(3a-e)$, $K_{NC} := \frac{-2b^2 g}{u - \sqrt{u^2 + 8gb^2\phi_1^2}}$; $K_C := \frac{\phi_4 \tau g + \psi_C u_C}{2\phi_1^2}$ and $K_{(1,2)} := \frac{-gb^2}{\phi_4 g - u_{(1,2)}\psi_{(1,2)}}$. If the coalition structure (1,E),2 occurs (or its symmetric counterpart (2,E),1) the EMU is directly involved in the game (i.e. the common interest rate generally differs from zero). As a consequence the theoretical formulae become much more involved. Therefore they are omitted here.

In the rest of this section we will restrict to the case that $e < a$ and we will assume, moreover, that as well $-\phi_4$ as e are positive. For a broad class of realistic model parameters these assumptions hold. As a consequence, the non-cooperative game has a uniquely defined equilibrium. Furthermore, unless stated otherwise, we will restrict our analysis to the non-cooperative and the cooperative cases, and the coalition structure (1,2),3 where we also assume that the bargaining power of each government is equal to $\frac{1}{2}$.

Then we observe two striking things: $f_1 = -f_2$ and the ECB does not influence the game, neither in a direct way (i.e. $i_E = 0$) nor in an indirect way (i.e. via its parameters). These statements do not hold for the coalition structure (1,3),2. There, the fiscal instruments differ and the ECB uses her instruments actively to reach her goals. The symmetry assumptions are crucial too: if they are dropped, the ECB also gets actively involved into the game.

Since we have explicit formulae for the various cost functions we exploit these to derive some further general conclusions. The first observation is that the convergence speed satisfies the following properties.

Theorem 1. i) $\psi_C = \psi_{(1,2)}$, ii) $\psi_{NC} < \psi_C$, iii) $\psi_i(g)$ is a monotonically increasing function with $\psi_i(0) = 0$ and $\psi_i(\infty) = -\phi_4$ for $i \in \{NC, C, (1,2)\}$.

With respect to the performance criteria we obtain the following results:

Theorem 2. i) $J_C^i = J_{(1,2)}^i$ for $i \in \{1,2\}$, ii) $J_C^E = J_{(1,2)}^E = J_{NC}^E = 0$.

According to *i)*, the costs for the fiscal players are the same in the cooperative case and the fiscal coalition case. In other words, the fiscal players are indifferent between these modes of play. According to *ii)*, the ECB is indifferent between the three different cases in this symmetric EMU. In other words, she has little to gain from coordination of her monetary policy with the national fiscal policies in (close to) symmetric settings.

4. ENDOGENOUS COALITION FORMATION

In analyzing endogenous coalitions in the first stage of the proposed two-stage game, we restrict our attention to three possible mechanisms of coalition formation: the coalitional Nash equilibrium (CNE), the sequential negotiation equilibrium (SNE), and the farsighted coalitional equilibrium (FCE). These equilibria can be informally described as follows (for formal definitions see Di Bartolomeo and Plasmans (2001) and the references in that paper).

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. More formally the CNE is characterized by two properties: the profitability property (i.e. the coalition losses must be lower than or equal to the non-cooperative ones for all coalition members) and the stability property (the loss of each coalition member must be lower than or equal to the loss of the same policy-maker when she defects from the coalition and the other members do not change their strategies). The stability property guarantees that the equilibrium is self-enforcing.

Several game-theoretical economists have defined some solution concepts based on the idea of indirect domination. We follow their approach by simply defining the FCE as an equilibrium where players foresee the reaction of the other ones to their actions (i.e. they make rational conjectures about the other players' behavior in replying to their actions). We simply assume that each policy-maker will consider how many policy-makers will leave the coalition if she will leave it. Formally, the FCE – in this simple 3 players' game – differs from the CNE only for the stability condition of the grand coalition. In other words, considering the FCE the grand coalition can be an equilibrium of the game even if it violates the stability condition when this violation leads to an unstable coalition, provided that the grand coalition is profitable..

An SNE is an equilibrium of a hierarchical multistage negotiation process. The negotiation starts with one policy-maker who proposes a coalition. The order of agents that can propose a coalition is given by an exogenous rule (i.e. rule of order). Each prospective member can reject or accept the proposal in the order determined by this fixed rule. If one of the policy-makers rejects the proposal, that policy-maker 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 reached.

5. NUMERICAL SOLUTION

Parameters are chosen on the basis of reasonable evidence (see Neck and Dockner, 1995). The semi-elasticity of the demand for domestic output with respect to the real interest rate is $\gamma = 0.5$, the elasticity of the demand for domestic output with respect to the competitiveness is $\delta = 1$, the elasticity of the demand for domestic output with respect to the foreign output is $\rho = 0.3$, the elasticity of the demand for domestic output with respect to the fiscal index is $\eta = 1$, the Phillips curve coefficient is $\xi = 0.75$, the policy-makers' bargaining powers are assumed to be equal (i.e. $\tau = \frac{1}{3}$) and the intertemporal discount factor is $\theta = 0.1$. The initial state of the EMU economy is assumed to be at $s_0 = 0.05$ (implying an initial disequilibrium of 5% in competitiveness between the two countries).

In the simulation we focus on the policy-makers' priorities and on their bargaining power distribution. We assume that both governments' priority is real output stabilization while the ECB is mainly concerned about price stabilization. The following preference weights in the policy-makers' objective functions are assumed: $\alpha = 0.2$, $\alpha_E = 0.8$, $\beta = 0.4$, $\beta_E = 0.3$ and $\chi = 0.15$.

Solving the procedure described in section 2 we get the following optimal costs.

Table 2 – Policy-makers' losses

	NC	C	$(1,2)$	$(1,E)$	$(2,E)$
J^1	0.23	0.12	0.12	1.96	0.06
J^2	0.23	0.12	0.12	0.06	1.96
J^E	0	0	0	1.10	1.10

From table 2 we can represent the second stage of the game in a payoff matrix form (notice that in this paper payoffs will be expressed in losses). Each agent can cooperate (c) by sharing its loss function with that of the other cooperative policy-makers or defect (d) playing as a singleton. The payoff matrix is described by table 3. It reads as follows: the country 1's government chooses rows, the country 2's government chooses columns and the ECB chooses boxes (among A and B). Notice that, when only one policy-maker follows the cooperative strategy, the equilibrium outcomes are clearly those of the non-cooperative (NC) case. In fact, in this case, this policy-maker will not find another policy-maker with whom to share her preference (see the problem defined by the J^C and J^S equations). Therefore, strategy profiles[3] $\{c,d,d\}$, $\{d,c,d\}$, $\{d,d,c\}$ and $\{d,d,d\}$ are associated with the same equilibrium in the second stage (i.e. NC in table 2).

Table 3 shows the following points. a) When the central bank plays d, the dominant strategy of both governments is to play c; b) When the central bank plays c, the dominant strategy of both governments is to play d. For the central bank it is indifferent to play d or c. However, these alternative decisions have a very different impact on the other players' losses. Moreover, if we assume that players prefer to cooperate (if the losses associated with d and c are the same, given the other players' strategies) the central bank's "good intention" paradoxically leads to the non-cooperative solution. This result derives

[3] Each strategy profile is the vector of the policy-makers' strategies, the first entry is the strategy of government 1, the second of government 2 and the third of the ECB.

from a lack of communication (a common result in this kind of game – see Echia and Mariotti (1998)). However, this could not be the case when the different assumptions about the endogenous coalition formation (and, therefore, about the agents' information set) are considered.

Table 3 - Payoff matrix

			2		
		d	*c*	*d*	*c*
1	*d*	0.23	0.23	0.23	0.06
		0.23	0.23	0.23	1.96
		0	0	0	1.10
	c	0.23	0.12	1.96	0.12
		0.23	0.12	0.06	0.12
		0	0	1.10	0
		A		B	
		d		*c*	
		ECB			

In fact, consider the endogenous coalition formation mechanisms described in the above section. The grand coalition and the governments' partial coalition satisfy profitability, and therefore, are the only candidates for the CNE. However, only the governments' partial coalition also satisfies the stability requirement. In fact both governments have an incentive to deviate from the grand coalition. Hence the fiscal coalition is the CNE. On the contrary, when the FCE is considered, also the grand coalition becomes an equilibrium since the ECB has no incentive in deviating and both governments foresee that a non-cooperative behavior leads to an unstable position (i.e. partial cooperation between the ECB and one government). Therefore, by comparing their payoffs with the final stable position (i.e. the non-cooperative one), they prefer to remain in the grand coalition. Hence both the grand coalition and the fiscal one are FCE. Considering the SNE we can observe that the grand coalition and the fiscal one are first best for the ECB. For both governments it is optimal to play as a singleton against a coalition formed by the two other policy-makers, while the grand coalition or a fiscal coalition is for both of them a second best choice. However, since there is no chance that a partial coalition with the ECB is formed,[4] it is always optimal for the ECB as a first mover to propose the grand coalition and for the other agents it is optimal to accept that proposal. When one of the governments plays first, the optimal proposal can be either the grand coalition or the fiscal one and for the other agent(s) it is optimal to accept that proposal. The grand coalition (or the fiscal coalition when the ECB is not the first mover) represents the SNE of our game.

[4] A policy-maker cannot propose to the other policy-makers a coalition where she is not involved. However, even if such a partial coalition between one government and the ECB were proposed, it will be not accepted since it is not profitable.

6. CONCLUSION

In this paper we have studied the coalition formation issue and have introduced two further steps into the literature by analyzing how coalitions are formed under different institutional settings and what are the effects of coalition formation and power distribution on economic policies. We have shown that when the coalition formation game is played without communication among the policy-makers, cooperation is either impossible or limited. However, when the policy-makers can communicate, full cooperation (as well as partial cooperation between a subset of countries) becomes possible in equilibrium, whereas complete non-cooperation is not sustainable in equilibrium. This contrast provides broad support for the view that institutions and international forums for discussion can play a crucial role in achieving international cooperation, even when these institutions are not endowed with enforcement powers.

REFERENCES

van Aarle, B., J.C. Engwerda and J.E.J. Plasmans (2001). Monetary and fiscal policy interaction in the EMU: A dynamic game approach. *Working Paper* No. 437., CESifo, Munich.

Demertzis, M., A. Hughes Hallett and N. Viegi (1999). Can the ECB be truly independent? Should it be?. *Empirica*, **26**, pp. 217-240.

Di Bartolomeo, G. and J.E.J. Plasmans (2001). Endogenous coalition formation and stabilization policies in a monetary union. mimeo.

Echia, G. and M. Mariotti (1998). Coalition Formation in International Environmental Agreements and the Role of Institutions. *European Economic Review*, **42**, pp. 573-582.

Engwerda, J.C., B. van Aarle and J.E.J. Plasmans (2001). Cooperative and noncooperative fiscal stabilisation policies in the EMU. *Journal of Economic Dynamics and Control*, forthcoming.

Hughes Hallett, A. and Y. Ma (1996). Changing partners: the importance of coordinating fiscal and monetary policies within a monetary union. *The Manchester School of Economic and Social Studies*, **64**, pp. 115-34.

Neck, R. and E.J. Dockner (1995). Commitment and coordination in a dynamic game model of international economic policy-making. *Open Economies Review*, **6**, pp. 5-28.