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Hamburgisches Welt-Wirtschafts-Archiv (HWWA)
Hamburg Institute of International Economics
Neuer Jungfernstieg 21 - 20347 Hamburg, Germany
Telefon: 040/428 34 355
Telefax: 040/428 34 451
e-mail: hwwa@hwwa.de
Internet: http://www.hwwa.de

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Hamburg Institute of International Economics (HWWA)
Neuer Jungfernstieg 21 - 20347 Hamburg, Germany
e-mail: hwwa@hwwa.de

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Competing coalitions in international monetary policy games

ABSTRACT

In Kohler (2002) we analyse coalition formation in monetary policy coordination games between n countries. We find that positive spillovers of the coalition formation process and the resulting free-rider problem limit the stable coalition size: since the coalition members are bound by the union's discipline, an outsider can successfully export inflation without fearing that the insiders will try to do the same.

In this paper, based on the same model, we allow countries to join competing coalitions. The formation of a large currency bloc is not sustainable since it would impose too much discipline on all participants. However, the co-existence of several smaller currency blocs may be a second-best solution to the free-riding problem of monetary policy coordination.

JEL classification: F33, F42.

Keywords: Currency unions; international policy coordination; Free-riding; Coalition formation.

Marion Kohler
Reserve Bank of Australia
65 Martin Place
Sydney NSW 2000
E-mail: kohlerm@rba.gov.au

1 Introduction

In the global monetary system we can observe the development of several currency blocs or, at least, areas where one currency plays a predominant role. The literature on optimal currency areas explains the existence of several (optimal) currency areas with asymmetries in trade structures, shocks or factor mobility. While historical evolution, geographical closeness and links in other policy areas undoubtedly play an important role in determining currency blocs, it is interesting to ask whether there are economic reasons other than asymmetries that could drive international currency arrangements.

This paper focuses on one type of gain from joining a union only, the gain that arises from coordination of monetary policies after a common shock. In the model by Canzoneri and Henderson (1991) after a negative supply shock countries try to export inflation via an appreciation of the exchange rate. Without cooperation, because all countries are doing so, none of them succeed but they all have contracted their money supply too much. This provides the 'classical' argument for the benefits from coordination in Hamada's (1976) seminal article: all countries could do better by agreeing not to try to export inflation.

The model in Kohler (2002) allows for explicit formation of a coalition by extending Canzoneri and Henderson's (1991) set-up to n countries: some countries can join a union while others remain outside. Since the union members are now bound by the coalition's discipline, an outsider can successfully export inflation without fearing that the insiders try to do the same. These additional 'gains from staying out' are the reason why the largest stable coalition comprises some but not all countries, even in the case of symmetric shocks.

In this paper we extend Kohler's (2002) result by allowing the outsiders to join a competing second coalition. We consider two strategic set-ups: one model where the two coalitions are formed at the same time, and countries have the option to join either; and a second model where one coalition is formed first, and the outsiders have then the option to form a second coalition. For a large range of parameters we can show that – depending on the strategic position – there will be either two (small) coalitions of the same size or the 'leading' coalition will be smaller than the 'follower' coalition. The conclusion is that in our model outsiders are willing to accept some discipline in a small union but not the larger discipline in a 'grand' coalition. As a result, the formation of several smaller blocs may be the outcome of individually optimal decisions.

The paper here focuses on *one* type of cost only: the possibility of free-riding on the coalition's discipline when remaining outside. This complements existing research in a number of ways and provides important insights into the feasibility of coalition formations and therefore co-existence of currency blocs.

Asymmetries are often seen as the driving force for coalition formation - reflecting optimum currency area considerations whereby idiosyncratic shocks are the main reason for a country not wanting to join a monetary union. This is reflected in existing papers on international policy coordination involving both a union and outsiders such as Buiter et al. (1995), Canzoneri (1982) and Canzoneri and Henderson (1991). Their distinction of insiders and outsiders stems explicitly or implicitly from asymmetries in the underlying economies. Asymmetries are also the implicit reason for the formation of currency blocs in empirical studies, such as Bayoumi and Eichengreen (1994) or Artis et al. (1998). Martin (1995) is closest to our analysis of free-riding incentives that restrict the coalition size. In a model with three countries he shows that economic convergence of a high-inflation country to a low-inflation union may lead to the build-up of these free-riding incentives. Since he restricts himself to a Phillips curve as representation of an individual economy and combines the issue of free-riding with convergence it is difficult to disentangle the relative contribution of these features. Indeed in a symmetric set-up in his model all countries would join the union. In contrast, in our models not all countries automatically join the coalition even in the symmetric case. We argue that it is not asymmetries but the type of externalities (i.e. strategic complements rather than substitutes) which is the reason for the existence of free-riding incentives.

The next section presents the basic shock stabilization game from Kohler (2002). The model underlying this is Canzoneri and Henderson (1991), extended to n countries. Readers who are familiar with their model or with Kohler (2002) may want to skip that section. Section 3 analyzes the formation of two coalitions using a two-stage game. Section 4 concludes.

2 The underlying economy

Since coalition formation is at the core of this paper we use a model with n countries where the individual country's economy is based on Canzoneri and Henderson (1991). All variables represent deviations of actual values from zero-disturbance equilibrium values, and, except for the interest rate, are expressed in terms of logarithms. The domestic country's variables are indexed by i; $j = 1 \ldots n, j \neq i$ denote the foreign countries. We focus our attention on a completely symmetric structure, restricting ourselves to examining the case of a productivity shock x that affects all countries in the same way.

Each country specializes in the production of one good. Output y_i increases in employment l_i (where $1 - \alpha$ is the elasticity of output with respect to labor) and decreases with some (world) productivity disturbance x (independently distributed with mean 0):

$$y_i = (1-\alpha)l_i - x \qquad\qquad 0 < \alpha < 1 \tag{1}$$

Profit-maximizing firms demand labor up to the point at which real wages (nominal wages w_i minus the output price of the home good p_i) are equal to the marginal product of labor:

$$w_i - p_i = -\alpha l_i - x \tag{2}$$

In equilibrium, the money supply m_i satisfies a simple Cambridge equation:

$$m_i = p_i + y_i \tag{3}$$

Monetary policy is effective because the monetary authorities have an information advantage arising from the timing of the game. They set the money supply when they know about the shock. Wage-setters fix nominal wages at the beginning of the period before they can observe the realization of the shock. They set w_i so as to minimize the expected deviation of actual employment from full employment ($\bar{l}_i = 0$):

$$w_i = m_i^e \tag{4}$$

with m_i^e the expected money supply deviation and w_i the deviation from the full-employment wage-level. Actual labor demand might differ due to unexpected disturbances, but wage-setters guarantee that labor demanded is always supplied.

The real exchange rate z is defined as the price of the foreign good in terms of the domestic good:

$$z_{ij} = (e_{ij} + p_j - p_i) \tag{5}$$

e_{ij} is the nominal exchange rate, i.e. the price of the currency of country j in terms of the domestic currency.

The demand for the good produced in the home country is:

$$y_i = \delta \sum_{\substack{j=1 \\ j \neq i}}^{n} z_{ij} + (1-\beta)\epsilon y_i + \frac{1}{n-1} \sum_{\substack{j=1 \\ j \neq i}}^{n} \beta \epsilon y_j - (1-\beta)\nu r_i - \frac{1}{n-1} \sum_{\substack{j=1 \\ j \neq i}}^{n} \beta \nu r_j \tag{6}$$

Consumers consume the fraction ϵ of their income y_j. They spend the share β of their expenses on foreign goods and the rest $(1-\beta)$ on the domestic good. Demand for the domestic good rises with y_j, $j = 1, \ldots, n$. A rise in the relative price of a foreign good shifts world demand from the foreign good to the home good by δ. The demand for all goods decreases with expected real interest rates r_i. The residents in each country spend the amount ν less for each percentage point increase in the expected real interest rate.

The consumer price index q_i is an average of the home good's and the foreign goods' price levels weighted analogous to the structure of the goods demanded. Price increases abroad raise the domestic consumer price level through the share of imported goods.

$$q_i = (1-\beta)p_i + \beta \frac{1}{n-1} \sum_{\substack{j=1 \\ j \neq i}}^{n} (e_{ij} + p_j) \tag{7}$$

The expected real interest rate is:

$$r_i = i_i - q_i^e + q_i \tag{8}$$

where i_i is the nominal interest rate and q_i^e is the expected value of the consumer price index tomorrow based on the information available today.

International capital mobility and perfect substitutability of bonds give the condition of uncovered interest rate parity, ensuring that private agents are indifferent between holding either of the bonds:

$$i_i = i_j + e_{ij}^e - e_{ij} \tag{9}$$

2.1 Policymaker's objectives

The policymaker has access to a single policy instrument m_i, which we identify with money growth. He evaluates the effects of monetary policy according to a loss function over the deviation of employment and inflation from the zero-disturbance equilibrium. The parameter σ denotes the relative weight of the objective 'full-employment':

$$L_i = \frac{1}{2}(\sigma l_i^2 + q_i^2) \tag{10}$$

2.2 Reduced form of the economy's behavior

We can reduce Eqs. (1) to (9) in the symmetric case to two equations for each country.[1] They determine the constraints for the policymaker's optimization problem. The money supply m_i is free as an instrument for optimizing the loss function.

The reduced forms for l_i and q_i are:

$$\begin{aligned} l_i &= m_i & (11)\\ q_i &= \lambda m_i - \kappa \sum_{\substack{j=1\\ j\neq i}} m_j + x & (12) \end{aligned}$$

with $\lambda = \alpha + \frac{\beta(1-\alpha)\left(1-\epsilon(1-\frac{n}{n-1}\beta)\right)}{\delta n+\nu(1-\frac{n}{n-1}\beta)^2}$ and $\kappa = \frac{\lambda-\alpha}{n-1}$; note that λ and κ are always positive.

First consider the effect of a reduction in domestic money supply. Each country's employment l_i falls one-for-one with the domestic money supply (Eq. (11)), and output falls. Since real wages have to rise (2), the price of the domestic good falls. The exchange rate appreciates in order to equilibrate goods markets ((5), (6)), thus lowering the price of imports. Consequently, the consumer price level, which is a weighted sum of the domestic good price and the prices of the imported goods, falls. This explains why λ in (12) is positive. Abroad, the price of imports is increased, thus causing inflation. Thus monetary policy creates an externality, which is reflected in the negative coefficient ($\kappa > 0$) of foreign monetary policy in (12).

Consider now a symmetric, negative world productivity shock ($x > 0$), which gives rise to a stabilization game. Without policy intervention, the shock would have no effect on employment because nominal output is unaffected. Real output falls and the output price rises by the same amount, since employment only remains constant if the real wage falls ((1), (2)).

[1] The reduced form of the economy can be derived in two steps. The reduced form for l_i can be derived by substituting Eqs. (4), (2) and (1) into (3), and using that $m_i^e = 0$. Deriving the reduced form for q_i involves substituting Eqs. (1)-(5) into (7), summation of Eqs. (6) and (8) over all countries, and substituting the terms in Eq. (7) (using also Eq. (9)).

There is no change in the real exchange rate since real output falls in all countries by the same amount. Consequently, the consumer price index rises. In short, a negative productivity shock will leave employment unchanged and increase CPI inflation.

Each policymaker now has an incentive to contract the money supply a little bit in order to lower inflation. He accepts the small loss from reducing employment below the full-employment level in favor of the significant gain from lowering inflation. But he also causes at the same time inflation abroad. If all policymakers perform anti-inflationary policies, they enter into a competitive appreciation. The exchange rate in the end remains unchanged but all policymakers have contracted too much with respect to their optimal money supply. This could be avoided if all countries coordinated on a less contractionary monetary policy.[2]

3 Bloc formation in a non-cooperative game

In the previous section we have outlined how policymakers will react to a negative productivity shock if they do not cooperate at all. Since they impose negative externalities on each other, the literature on monetary policy coordination has argued that coordination may be beneficial for all parties involved. Kohler (2002) analysed whether countries may prefer forming a coalition to full coordination. The main result of that paper was that a stable coalition may not include all countries, and, in fact, for a large range of parameter values in that model coalition formation will stop at three countries. The reason is that the coalition formation process itself causes positive spillovers for the outsiders: the increased discipline within the coalition reduces the negative externalities the coalition countries create for *all* countries, independent of whether they are ‘ins’ or ‘outs’. Countries will decide whether to join the union or not on the basis of whether it pays more to reduce imported inflation or to be able to export inflation.

But would countries which decided not to join the ‘first’ coalition prefer to form a second ‘competing’ coalition? The answer is provided in this paper: the outsiders are willing to undergo some discipline in a small union but not the larger discipline in a big union.

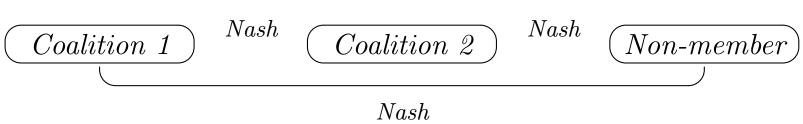
[2] Hamada (1976) pioneered the studies that uncoordinated policymaking across countries may be inefficient. The idea of shock stabilization after a negative productivity shock was formalized by Canzoneri and Gray (1985).

As in Kohler (2002) a coalition is defined as a subset of countries that optimize a common loss function. This common loss function is a weighted average of the member countries' loss functions. As all members have the same economic structure and the same loss function, we assume that the weights are equal.

- Coalition 1 consists of the countries $i = 1, \ldots k_1$ and optimizes: $\mathcal{L}_1 = \sum_{i=1}^{k_1} \alpha_i L_i = \sum_{i=1}^{k_1} \frac{1}{k_1} L_i$
- Coalition 2 includes the countries $i = 1, \ldots, k_2$ and optimizes: $\mathcal{L}_2 = \sum_{i=1}^{k_2} \frac{1}{k_2} L_i$
- The remaining $n - k_1 - k_2$ countries play a non-cooperative Nash strategy against all other countries by minimizing their individual loss functions.

In order to solve the optimization problem of the coalition members we have to clarify one further element of the structure of the game: the coalitions can be involved in a Nash game or in a Stackelberg game with the non-members and with each other.[3]

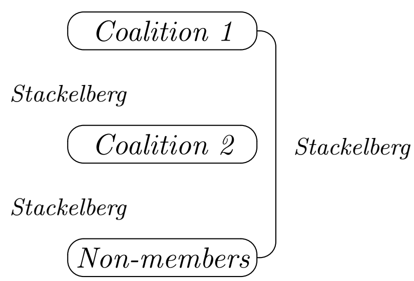
In the **Nash-Nash game** we assume that both coalitions play a Nash game against each other and against the fringe. One might identify such a structure with a situation where both coalitions are formed simultaneously. This game describes, for example, a situation where the formation of (regional) miniblocs is envisaged. This may either be the result of the break-up of a larger, perhaps political bloc such as the former Soviet Union or Yugoslavia, or it may be the result of newly evolving regional structures.[4]



[3]Note that the coalition outcome represented by a Nash equilibrium cannot be achieved without a commitment technology since the countries which play cooperatively within a coalition are off their individual Nash reaction functions. We have to assume that the coalition members can enter into a binding agreement that is known about by all players.

[4]The hierarchical relation between groups are illustrated in the graphs. Two groups which lie on the same horizontal line do not have hierarchical differences and hence play a Nash game against each other. Groups which are connected by a vertical line play a Stackelberg game against each other where the top group is the Stackelberg leader while the lower group represents the Stackelberg follower.

In the **Stackelberg-Stackelberg game** we will consider the situation where the "first" coalition plays a Stackelberg game against the "second", that is in the stabilisation game the first Stackelberg leader coalition will move first. The situation we have in mind is a commitment structure which might be explained by the timing in the coalition formation: in the beginning, coalition one is established and increased until it reaches a stable size. The remaining countries are given the choice to form a second coalition or to remain outside. They will form a second coalition until it reaches its stable size.[5] One example of such a structure may be whether outsiders to the euro area would consider forming a separate currency bloc, rather than join the existing monetary union.



Having clarified the strategic positions we can now solve the game. Following Yi (1997), we can formulate coalition formation as a two-stage game. In stage 1 countries irrevocably decide whether to join a coalition or not. In stage 2 countries engage in a shock stabilization game (given the coalition).

The game is solved recursively. First, equating the reaction functions of the countries outside the coalition and of the coalition itself yields the outcome of stage 2: the equilibrium for a given insider-outsider structure. This outcome is dependent on the number of coalition members k_1 and k_2. This is extended to an analysis of the individually optimal choices in stage 1: the 'stability' of the coalition, using an algorithm drawn from the industrial organization literature.

[5] For stability of the entire equilibrium, however, we will ensure that in the stable situation no country would like to leave its group.

3.1 Stage 2: The optimal strategies and the equilibrium

We assume that the first k_1 out of the n countries are members of the coalition C_1; countries $k_1+1,\ldots,(k_1+k_2)$ are members of coalition C_2 and countries $(k_1+k_2+1),\ldots,n$ are outside the coalitions.

3.1.1 The countries outside the coalition

In order to solve the policymaker's optimization problem when he is outside the coalition, we calculate the Nash strategy. The loss function (using Eqs. (11) and (12)) is minimized with respect to m_i, subject to given strategies of the other countries, $\overline{m}_{j,nc}$ for all outsiders and $\overline{m}_{j,c_1}$ or $\overline{m}_{j,c_2}$ for all coalition members. Since we have a symmetric structure, we assume that all countries outside the coalition have the same optimal money supply m^*_{nc}. We can then derive the money supply of a nonmember as a function of the coalitions' money supplies:

$$m^*_{nc} = \theta \sum_{j=1}^{k_1} \overline{m}_{j,c_1} + \theta \sum_{j=1}^{k_2} \overline{m}_{j,c_2} - \vartheta x \qquad \theta, \vartheta > 0 \tag{13}$$

with $\theta = \frac{\lambda\kappa}{\sigma+\lambda^2-\lambda\kappa(n-k_1-k_2-1)}$ and $\vartheta = \frac{\theta}{\kappa}$; note that θ and ϑ are always positive.

Eq. (13) shows that the optimal policy outside the coalition depends positively on the coalition policies, i.e. the money supplies of a nonmember and a coalition member are strategic complements. This means that a less contractionary monetary policy of the coalition members triggers a less contractionary response from the nonmembers. The reasoning is as follows: the coalition creates less competitive appreciation for the nonmembers by contracting less. Hence, the countries outside the coalition also need to contract less, because they face less 'imported' inflation.

3.1.2 The optimal strategy of the coalitions and the equilibrium: The Nash-Nash game

Coalition i ($i = 1,2$) as a whole plays a Nash game against the outsiders and against the other coalition, which means that it solves its optimization problem subject to a given money supply of the nonmembers and of the members of the other coalition. Using the symmetry assumption $m^*_{j,c_i} = m^*_{c_i}$ for all $j = 1,\ldots,k_i$ and all $i = 1,2$ we can derive a coalition member's reaction function. By equating all three reaction functions we obtain the equilibrium of the Nash game with a coalition as:

$$m_{c1}^* = -\underbrace{\frac{1}{\mu}(1+\kappa k_2\psi_2)(1+\kappa f\vartheta)\psi_1}_{\rho_1} x \tag{14}$$

$$m_{c2}^* = -\underbrace{\frac{1}{\mu}(1+\kappa k_1\psi_1)(1+\kappa f\vartheta)\psi_2}_{\rho_2} x \tag{15}$$

$$m_{nc}^* = -\underbrace{\frac{1}{\mu}(1+\kappa k_1\psi_1)(1+\kappa k_2\psi_2)\vartheta}_{\varrho} x \tag{16}$$

with $\mu = (1+\kappa k_1\psi_1)(1+\kappa k_2\psi_2) - (1+\kappa f\vartheta)(\kappa k_1\psi_1(1+\kappa k_2\psi_2) + \kappa k_2\psi_2(1+\kappa k_1\psi_1))$, $\psi_1 = \frac{\lambda-\kappa(k_1-1)}{\sigma+(\lambda-\kappa(k_1-1))^2}$ and $\psi_2 = \frac{\lambda-\kappa(k_2-1)}{\sigma+(\lambda-\kappa(k_2-1))^2}$; with some rearrangement it can be shown that ρ_1, ρ_2 and ϱ are always positive.

3.1.3 The optimal strategy of the coalitions and the equilibrium: The Stackelberg-Stackelberg game

In the Stackelberg game we can solve for the reaction functions recursively, again using the symmetry condition for the optimal policies of members within each group. Coalition 2 solves its optimisation problem by taking the reaction functions of non-members fully into account, but subject to a given strategy $\overline{m}_{j,c_1}$ of the members of the Stackelberg leader coalition. Coalition 1 (the Stackelberg leader) determines its strategies by taking the reaction functions of both members of coalition 2 and the outsiders into account. This determines then successively the equilibrium policies of coalition 2 and of the fringe.

The resulting equilibrium strategies are:

$$m_{c1}^* = -\omega_1 x \tag{17}$$

$$m_{c2}^* = -\underbrace{\eta_2(1+k_1\omega_1\kappa)}_{\omega_2} x \tag{18}$$

$$m_{nc}^* = -\underbrace{(\theta(k_1\omega_1+k_2\omega_2)+\vartheta)}_{\upsilon} x \tag{19}$$

with: $\omega_1 = \frac{(1+(n-k_1-k_2)\theta)(1+\eta_2k_2\kappa)(\lambda+\kappa-k_1\kappa(1+(n-k_1-k_2)\theta)(1+\eta_2k_2\kappa))}{\sigma+(\lambda+\kappa-k_1\kappa(1+(n-k_1-k_2)\theta)(1+\eta_2k_2\kappa))^2}$; again, with some rearrangement it can be shown that ω_1, ω_2 and υ are always positive.

3.1.4 Equilibrium losses

The losses in equilibrium for both set-ups are given by:

$$L_{c1} = \frac{1}{2}(\sigma m_{c1}^{*2} + (\lambda m_{c1}^{*} - \kappa(k_1 - 1)m_{c1}^{*} - \kappa k_2 m_{c2}^{*} - \kappa(n - k_1 - k_2)m_{nc}^{*} + x)^2) \quad (20)$$

$$L_{c2} = \frac{1}{2}(\sigma m_{c2}^{*2} + (\lambda m_{c2}^{*} - \kappa k_1 m_{c1}^{*} - \kappa(k_2 - 1)m_{c2}^{*} - \kappa(n - k_1 - k_2)m_{nc}^{*} + x)^2) \quad (21)$$

$$L_{nc} = \frac{1}{2}(\sigma m_{nc}^{*2} + (\lambda m_{nc}^{*} - \kappa k_1 m_{c1}^{*} - \kappa k_2 m_{c2}^{*} - \kappa(n - k_1 - k_2 - 1)m_{nc}^{*} + x)^2) \quad (22)$$

The equilibrium policies (14) to (19) all are linear functions of the shock x. If the shock is zero, the optimal policies are zero as well, since there is no need for a stabilization game. If the shock is negative, i.e. $x > 0$, the optimal policy for all countries is a contractionary monetary policy.

The coalition eliminates the negative externalities that the member countries impose on each other. Therefore the coalition members conduct a less contractionary, and thus less deflationary, policy and so lower their losses. But if the coalition countries contract less, the inflation in the nonmember countries is lower as well, since the currency of a coalition member appreciates less against all currencies. It means that the coalition formation process produces positive spillovers for nonmembers, since also their losses are lowered. For the same reason, members of a coalition benefit more from an increase in the size of the other coalition than from an expansion of their own coalition. The lowest losses are reached when all other countries are in the other coalition. The reason is clear: the more coalition members, the stronger is ‘coalition discipline’ from which all countries profit; the smaller the coalition size, the closer is the coalition policy to the individually optimal Nash response.

In the following, we will analyze whether there is a stable coalition size where the spillovers from the coalition formation process are high enough that a country prefers to join a second coalition or even prefers to join neither coalition.

3.2 Stage 1: the stability of coalitions in equilibrium

We will determine which coalition size is stable – if any – using a stability concept from the cartel literature by D’Aspremont et al. (1983). The loss function of a nonmember is denoted by $L_{nc}(k_1, k_2)$. If it joins coalition 1 (and no other country changes from one group to another), it will have the loss $L_{c1}(k_1+1,k_2)$. If $L_{nc}(k_1,k_2) < L_{c1}(k_1+1,k_2)$, the country has no incentive to join the coalition – the coalition is called 'externally stable'. A similar condition holds for the coalition members. The coalitions are *externally stable* if:

$$L_{c2}(k_1^*,k_2^*,n) < L_{c1}(k_1^*+1,k_2^*-1,n) \textit{ and } L_{nc}(k_1^*,k_2^*,n) < L_{c1}(k_1^*+1,k_2^*,n)$$
$$L_{c1}(k_1^*,k_2^*,n) < L_{c2}(k_1^*-1,k_2^*+1,n) \textit{ and } L_{nc}(k_1^*,k_2^*,n) < L_{c2}(k_1^*,k_2^*+1,n)$$

If $L_{c_1}(k_1,k_2) < L_{nc}(k_1-1,k_2)$, a member of coalition 1 has no incentive to leave coalition 1. The coalition is called 'internally stable'. The coalitions are *internally stable* with size k_1^*, k_2^* if:

$$L_{c1}(k_1^*,k_2^*,n) < L_{nc}(k_1^*-1,k_2^*,n) \textit{ and } L_{c1}(k_1^*,k_2^*,n) < L_{c2}(k_1^*-1,k_2^*+1,n)$$
$$L_{c2}(k_1^*,k_2^*,n) < L_{nc}(k_1^*,k_2^*-1,n) \textit{ and } L_{c2}(k_1^*,k_2^*,n) < L_{c1}(k_1^*+1,k_2^*-1,n)$$

If all conditions are fulfilled the coalitions are stable with size k_1^* and k_2^*, respectively.

Our stability conditions do not allow the coalition to block a further extension of the coalition. However, the coalition in our game would never want to limit entry since the coalition members' losses decrease when new countries enter the coalition. Hence we do not need a condition which ensures that 'free entry' is possible.[6]

We will now analyse whether the stable coalition sizes are larger than zero, but do not comprise all countries for sufficiently large n. In light of the number of parameters, the nonlinearities in the model, and the mixture of discrete and continuous variables, we have performed numerical simulations to establish the stable coalition for specific parameter values (the base scenario chosen was: $\alpha = \beta = 0.5$, $\epsilon = 0.8$, $\nu = 0.05$, $\sigma = 1$, $\delta = 0.3$ and $n = 22$). The result of a robustness analysis are presented in the Appendix. The precise numerical results change, but the conclusions carry over to other parameter sets.

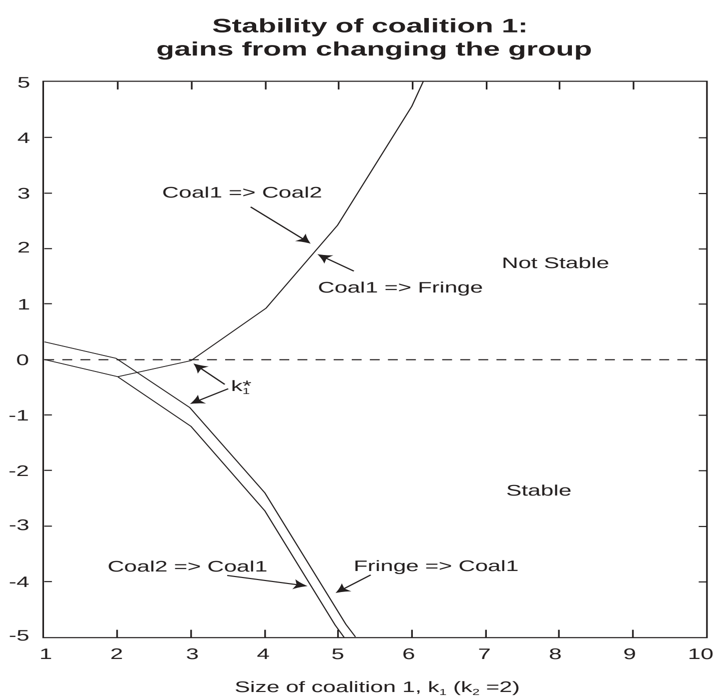
3.2.1 The Nash-Nash game

Figure 1 illustrates the stability conditions in the Nash-Nash game for different sizes of coalition 1 when there are only two countries in coalition 2. When coalition 1 has more than two members there are no incentives to join coalition 1 any more: the gains are negative.

[6] In contrast to our model, coalition formation which is based on reputational considerations, as in Alesina and Grilli (1993), faces this problem. It is not in the interests of the coalition to admit a 'weaker' member, which would deteriorate the 'stronger' members' positions.

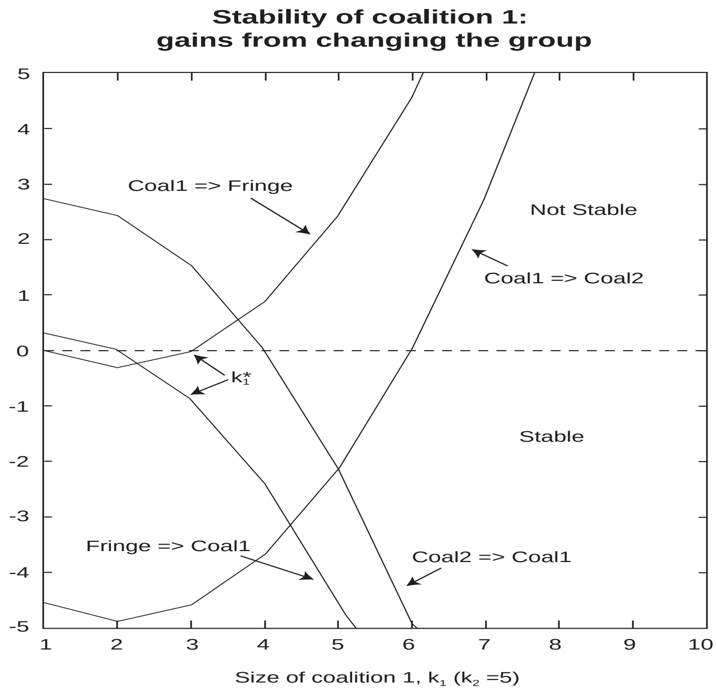
Members of coalition 2 prefer to remain in their own coalition which has only two members since they can benefit from the discipline in coalition 1 even if they are not members and they have to undergo less discipline themselves in their own smaller coalition. Members of the fringe would prefer to join the smaller coalition 2, if at all. The increasing decline of the graphs $Coal2 \Rightarrow Coal1$ and $Fringe \Rightarrow Coal1$ indicates that with increasing coalition size k_1 these disincentives to join coalition 1 become even larger, since the coalition-induced discipline which a joining member would have to undergo increases and outsiders benefit from the increasing coalition size. For three members in coalition 1 these members are indifferent between staying where they are or joining coalition 2 (and being its third member). For k_1^* more than three, coalition 1 members find it profitable to switch to the smaller coalition 2 or to join the fringe: the gains become positive. Here, the internal stability condition $Coal1 \Rightarrow Coal2$ fails to hold with inequality for $k \geq 3$ and this is the reason why there is no stable coalition size for coalition 1 when there are only two members in coalition 2.

Figure 1: Stability of coalition 1 with varying k_1(for $k_2 = 2$)[(a)]



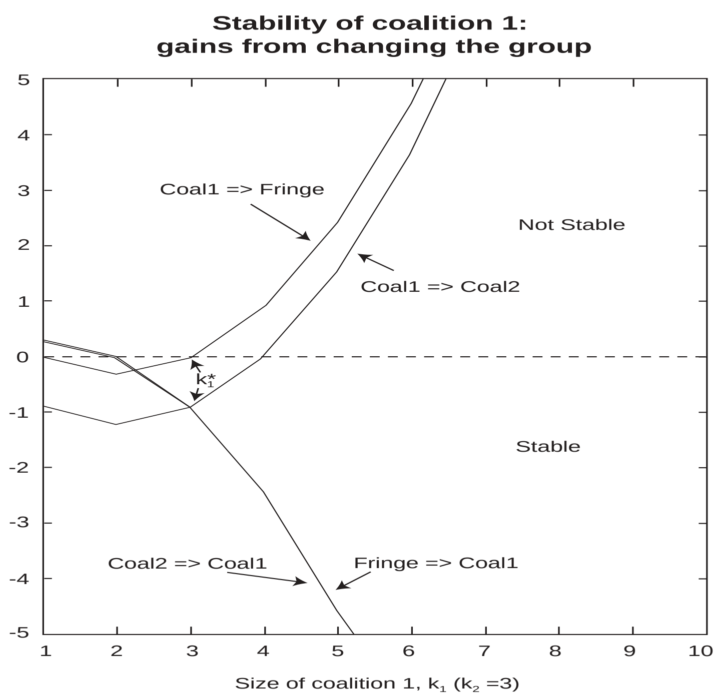
[(a)]Negative 'gains from changing the group' imply that the group is stable. The convex graphs show the internal stability conditions. The concave graphs show the external stability conditions. Here, no size of coalition 1 fulfils all stability criteria.

Figure 2: Stability of coalition 1 with varying k_1 (for $k_2 = 5$)[(a)]



[(a)] No coalition size fulfils all stability criteria.

Figure 3: Stability of coalition 1 with varying k_1 (for $k_2 = 3$)[(a)]



[(a)] Only coalition size three fulfils all stability criteria.

Figure 2 shows, on the other hand, the situation where there are $k_2 = 5$ countries in coalition 2, ie two more than the stable coalition size. Whereas the graphs of the switches between the fringe and coalition 1 are qualitatively the same as in chart 1, the graphs for the switches with coalition 2 have shifted. Members of coalition 2 benefit from switching to coalition 1 until the latter has more than 4 members; this will prevent a stable coalition size below this number. On the other hand, coalition 1 members will prefer to switch to the fringe when there are more than three members in coalition 1. Again, there is no stable equilibrium.

Figure 3 finally shows a stable equilibrium for coalition 1. It is for exactly three countries in both coalitions and all other countries in the fringe; no country wishes to switch between the fringe and coalition 1, or between the two coalitions. The three charts only show the stability conditions for coalition 1. Since the model is symmetric the respective graphs for coalition 2 are identical. As the stable equilibrium for coalition 1 is three, the stable equilibrium for coalition 2 is the same.

Comparison of all three charts shows that two graphs shift with increasing k_2 and two graphs do not change their values very much. The two graphs which remain unchanged are the potential gains from switching between the fringe and coalition 1. The reason is evident: both groups benefit in exactly the same way from an enlargement of coalition 2 against whom both groups play a Nash game. Hence, the relative positions which determine the gains from switches between the groups remain unchanged. The two graphs which determine the profitability of switching between coalition 1 and 2, however, shift with the size of coalition 2. The more countries there are in coalition 2, the less the incentive for a member of coalition 1 to join coalition 2. When coalition 2 has two members, a coalition 1 member for $k_1 = 3$ will be indifferent between joining either of the coalitions. Only when coalition 1 has more than three members will it be profitable to switch to coalition 2. A similar argument applies for the gains from switches between coalition 2 and coalition 1. Only when there are fewer members in coalition 1 than in coalition 2 will a member of coalition 2 not lose by switching to coalition 1. Hence, both graphs $Coal1 \Rightarrow Coal2$ and $Coal2 \Rightarrow Coal1$ shift to the right with increasing k_1. Whereas the first permits stable coalition sizes only for k_1 which is less than or equal to k_2, the latter shows stable coalition sizes which have at least k_2 members. In Chart 1 it is $Coal1 \Rightarrow Coal2$ which prohibits a stable coalition size of three which is the stable size implied by the conditions not to switch to the fringe. In Chart 2 it is $Coal2 \Rightarrow Coal1$ which is negative only above $k_1 = 4$ and therefore fails to give stability for a lower k_1.

The Nash-Nash game has an equilibrium where each coalition has three members if there are more than five countries in the world. In a Nash-Nash game with three countries, full coordination (ie all countries in one coalition) is the stable equilibrium. When there are four countries there will be two countries in each coalition in a stable equilibrium.[7] For $n = 5$ countries the 'last' country to enter is indifferent between the two coalitions, and so may switch between them in equilibrium. The stability conditions are only fulfilled with equality. However, the last country will clearly prefer joining one of the coalitions to remaining in the fringe. These results are independent of the total number of countries, in particular of the number of countries in the fringe, once the total number of countries exceeds five. The features of these results will be explained in detail later.

The stable coalition size remains small since the money supplies are strategic complements, that is a less contractionary money supply reduces losses for both insiders and outsiders. By the same token, it can be explained why it is individually optimal to form two coalitions of three countries but not one coalition of six which may be Pareto-superior to the two 3-country blocs. It has to be borne in mind that a coalition is only stable when it is *individually* optimal for each single country not to join the coalition (for a country in the fringe or in the other coalition) or not to leave the coalition (for a country in the coalition under consideration). Countries would undergo the increase in discipline from a 2 to a 3-country coalition, however, increasing coalition discipline and increasing free-riding possibilities at the same time prevent them from joining a coalition which has more than three countries. Therefore, the step from a 3 to a 6-country coalition is not incentive-compatible and countries would leave a coalition of 6 countries.

The analysis above shows another feature: the symmetry of the Nash-Nash game implies that the potential switches between the countries force a stable equilibrium to have the same coalition sizes for both coalitions, as long as n is large enough and stability has to be fulfilled with strict inequality. If coalition sizes are different, it would pay for a country to switch between the coalitions. Hence every combination which gives the same coalition sizes for both countries is stable against switches between the coalitions. It is the trade-off with the

[7] For $n = 4$ countries some cases have a very high κ such that it pays off to extend the first coalition to the stable size of three rather than having two countries in each coalition.

fringe which forces the system into a unique stable equilibrium of $k_1 = k_2 = 3$. This also explains why the stable coalition size is 3 for most parameter values, since this was also the result in Kohler (2002) where there is only one coalition.

Although the results have only been analysed for the case of two coalitions, one may speculate about what happens if there are three coalitions, four coalitions etc. The answer seems to be straightforward in the case where the coalitions play a Nash game against each other: the stable coalition size is determined by the trade-off between the fringe and co-operation within *one* of the coalitions. In the model here, the stable equilibrium of three countries in each coalition is 'dynamically' stable in the sense that it always pays for two countries to 'open' a new coalition and for a third one to join them. It pays as well for a fourth country which might have 'accidentally' joined the coalition to leave it again. Hence including more coalitions should be straightforward, ie countries will prefer splitting up in small blocs of equal size to both alternatives, staying in the fringe or forming a big coalition. In the former case, they gain from free-riding on the coalition discipline but they lose from incurring negative spillovers from non-cooperative policies with the other fringe countries. In the latter case, they gain from internalising the externalities with the other coalition members, however, they suffer too much coalition discipline. To join a smaller bloc seems to offer a 'balanced' solution to this cost-benefit analysis. Hence, there are mechanisms which exist in a symmetric world and are intrinsic to the process of coalition formation which can explain the existence of blocs that coordinate monetary policies. By contrast, the literature on optimum currency areas explains this phenomenon with asymmetries in the economic structures of the countries belonging to different blocs.[8]

3.2.2 The Stackelberg-Stackelberg game

In the Stackelberg-Stackelberg game the corresponding figures are very similar to those shown for the Nash-Nash game, though the numerical values change somewhat. For more than four countries coalition 1 consists of only two countries, coalition 2 of three countries in the stable equilibria. This is the result for more than four countries. For $n = 3$ countries the stable equilibrium has two countries in coalition 2 and none in coalition 1, for $n = 4$ countries both coalitions have a stable size of two countries.

[8] An example of an empirical study is Bayoumi and Eichengreen (1994).

The strategic position *between* the two coalitions is crucial for this result. In the game where the coalitions play a Nash game against each other the stable coalition sizes are the same and determined by the trade-off with the fringe. This feature changes only when a difference in strategic positions of the coalitions is assumed.

The reason for the change in the stable coalition sizes is based on the argument outlined already above, ie that Stackelberg followers are better off than Stackelberg leaders in a game with strategic complements. Coalition 1, the 'double' Stackelberg leader, loses some of its strategic advantage against coalition 2 and the fringe which changes the relative positions sufficiently in order to result in a lower stable coalition size for the top coalition. The change in strategic 'equality' between the coalitions now allows an equilibrium which is not symmetric in the coalition sizes.

Extending this game to more than two coalitions is not as straightforward as in the Nash case. The top coalition is smaller since the Stackelberg follower's profit is higher in games with strategic complements. If another 'top' coalition is added, this effect certainly will be higher and the stable coalition size will be even smaller for this top coalition. Hence, a Stackelberg structure *amongst the coalitions* may set a limit to the maximum number of coalitions. However, a strict Stackelberg hierarchy of several blocs may be rather unrealistic and difficult to explain. An additional problem arises in justifying why one or two countries are a Stackelberg leader in a symmetric model. Therefore, an extension of this result to more than two coalitions may be more difficult.

4 Conclusions

The exercise in Kohler (2002) has shown that – in the framework of a standard international policy coordination model – the explicit possibility of coalition formation gives results different from the ones often assumed for coordination models with more than two countries. Coalition formation will stop at a coalition size which does not comprise all countries if the choice whether to join a coalition or not has to be incentive compatible for the individual country.

In this paper we have highlighted the possibility that several coalitions may coexist as an outcome of individually optimal decisions. We have found two results. First, countries will find it profitable to form several coalitions of a smaller size rather than forming one big coalition or not forming a coalition at all. If the coalitions are in the same strategic position the coalition sizes in a stable equilibrium are the same. The specific stable coalition size is then determined by the trade-offs between entering a coalition or staying in the fringe. An extension to more than two coalitions seems to be straightforward, and will lead ultimately to the result that all countries will form a coalition with some other countries. These coalitions, however, will be of a rather small size when there are many countries.

Secondly, if there are differences in the strategic position of the coalitions the result changes. Due to the strategic complementarity of international monetary policy the 'leading' coalition turns out to be the least profitable group. Consequently, less countries will want to join it in a stable equilibrium than the other coalition. In this case, an extension to more than two countries is not straightforward. Possibly, a structure of 'power' amongst coalitions will set an early end to the formation of coalitions.

A Stability in the Nash-Nash game

In the following, we will present the results of the simulation analysis. The values if not noted otherwise, are:

$$\alpha = \beta = \tau = 0.5, \;\; \nu = 0.05, \; \delta = 0.3, \;\; \sigma = 1,$$

The sensitivity analysis was performed by varying all parameters between 0.1 and 0.9, increasing in steps of 0.1. σ, the relative weight of the employment target, starts with 0.1 and increases in steps of 0.5 to 10 (univariate) and from 1 to 10 in steps of 1 (multivariate).

For the Nash-Nash game, the results of the simulation analysis were already discussed in detail in Section 3. Therefore, attention will be restricted to the results of the robustness analysis.

Table 1: *Nash-Nash:* univariate sensitivity analysis

Parameter		*Number of countries n =*						
		4	5	6	7	8	9	10
α	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)	(3,3)
β	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)	(3,3)
δ	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)	(3,3)
ϵ	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)	(3,3)
ν	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)	(3,3)
σ	0.1-10	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)	(3,3)

Univariate analysis

Table 1 shows the results of the univariate analysis where the number of countries n was varied from 3 to 20; the results from 3 to 10 are reported here. The pairs of numbers in the tables represent the stable coalition sizes. While the first number indicates the stable size of coalition 1, the second number represents the stable size of coalition 2. In the univariate analysis the stable coalition size is always unique, at three, when the number of countries exceeds five. For $n = 4$ countries the stable coalition sizes are two for each coalition, and for $n = 5$ countries the 'fifth' country is indifferent between coalition 1 or 2 when both already have two members.

Table 2: *Nash-Nash:* multivariate sensitivity analysis (σ, α, β)

Parameter			*Number of countries n =*					
σ	α	β	4	5	6	7	8	9
1	0.1-0.2	0.1-0.7	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
		0.8-0.9	(3,1),(1,3)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
	0.3	0.1-0.8	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
		0.9	(3,1),(1,3)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
	0.4-0.9	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
2-10	0.1-0.9	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)

Multivariate analysis

Table 2 shows the results of a simultaneous variation of σ, α and β; Table 3 presents the results of the variation of δ, ϵ and ν. The number of countries n ranges from 3 to 20; the results from 3 to 9 are included. The pairs of numbers in the tables represent the stable coalition sizes.

Table 3: *Nash-Nash:* multivariate sensitivity analysis (ϵ, ν, δ)

Parameter			*Number of countries n =*					
ϵ	δ	ν	4	5	6	7	8	9
0.1	0.1	0.1-0.5	(3,1),(1,3)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
		0.6-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
	0.2-0.9	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
0.2-0.3	0.1	0.1-0.3	(3,1),(1,3)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
		0.4-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
	0.2-0.9	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
0.4	0.1	0.1	(3,1),(1,3)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
	0.1-0.9	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)
0.5-0.9	0.1-0.9	0.1-0.9	(2,2)	(2,3),(3,2)	(3,3)	(3,3)	(3,3)	(3,3)

If n exceeds four countries the results of the 'standard' equilibrium which are discussed in Section 3.1 do not vary with the parameter values. Only for $n = 4$ countries are there some cases where the stable coalition sizes are three and one, rather than two and two. This situation occurs when α is very low and β is very high or when δ is very low. Both situations imply that κ, which indicates the impact of negative spillovers from non-coordinated policies, is high. When negative externalities imposed by non-coordinated policies are large it pays to extend the first coalition to the stable size of three rather than having two countries in each coalition.

B Stability in the Stackelberg-Stackelberg game

The results of the simulation[9] of the Stackelberg-Stackelberg game are summarized in the following. Though the results do not differ quantitatively very much from the Nash-Nash cases we have qualitatively different results in the stability analysis.

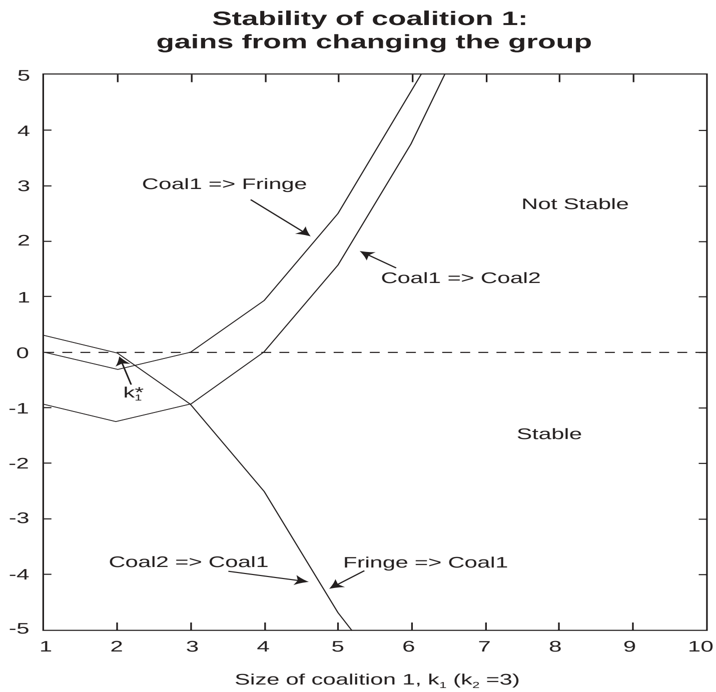
As in the Nash-Nash game the stability conditions between the coalition and the fringe remain almost unchanged with increasing coalition size of coalition two. They imply a stable coalition size around three where it does not pay off to join or leave the coalition. The gains from switching between the two coalition are dependent on the coalition sizes. Essentially, it will mostly be preferable to be in the coalition with less members. As above, for a small size of coalition two only few countries will be in coalition one and, hence, the internal stability of coalition one is a problem. When coalition two is larger countries will prefer to switch to the smaller coalition one. Here, an external stability condition fails to hold for smaller k_1. However, one has to take the different strategic position of the two coalitions into account which makes it preferable to be in coalition two (the Stackelberg follower) rather than coalition two. This changes the stable equilibrium now to a situation where there are only two countries in the 'leading' coalition one and three countries in coalition two. Figure 4 illustrates the stability conditions for the stable case where there are three countries in coalition two.

As in the Nash-Nash game, a univariate and a multivariate sensitivity analysis were performed.

All parameter values except for σ may vary between zero and one. We have tested the results by increasing the parameter values in steps of 0.1 from 0.1 to 0.9. σ, the relative weight of the employment target, may be any positive number. Consequently, we have tested the results

[9] Again, the results reported are based on a simulation of the model with the parameter values: $\alpha = 0.5, \beta = 0.5, \epsilon = 0.8, \nu = 0.05, \sigma = 1$ and $\delta = 0.3$. All figures refer to the case of $n = 22$ countries.

Figure 4: Stability of coalition one with varying k_1 (for $k_2^* = 3$)[a]



for a $\sigma = 0.1$ in steps of 0.5 up to a $\sigma = 10$ in the univariate analysis and from $\sigma = 1$ in steps of 1 up to $\sigma = 10$ in the multivariate analysis. The robustness analysis was performed as a univariate and a multivariate analysis.

Parameter		*Number of countries n =*								
		4	5	6	7	8	9	10	11	12
α	0.1-0.9	(2,2)	(2,3)[10]	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
β	0.1-0.8	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.9	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
δ	0.1	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.2-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
ϵ	0.1-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
ν	0.1-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
σ	0.1	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.6-10	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)

Table 4: *Stb-Stb.:* Univariate sensitivity analysis

Univariate analysis Table 4 shows the results of the univariate analysis where the number of countries n was varied from 3 to 20; we include here the results from 3 to 10. The pairs of numbers in the tables represent the stable coalition sizes. While the first number indicates the stable size of coalition one, the second number represents the stable size of coalition two. In the univariate analysis the stable coalition size was always unique and always two members in the 'leader' coalition and three members in the 'follower' coalition when the number of countries exceeds four. For $n = 4$ countries the stable coalition sizes are either two for each coalition or one member in the 'leader' coalition and three members in the 'follower' coalition. The latter case occurs when the negative externalities κ are very high (δ very low or β very high) or when σ is very low, that is the employment target has a low priority which stresses the importance of avoiding imported inflation by joining the coalition.

Parameter			*Number of countries $n =$*						
σ	α	β	4	5	6	7	8	9	10
1	0.1-0.3	0.1-0.7	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
		0.8-0.9	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.4-0.5	0.1-0.8	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
		0.9	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.6-0.9	0.1-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
2	0.1	0.1-0.8	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
		0.9	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.2-0.9	0.1-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
3-10	0.1-0.9	0.1-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)

Table 5: *Stb-Stb.:* Multivariate sensitivity analysis over σ, α, β

Multivariate analysis As above, the multivariate analysis was performed in two sets. While table 5 shows the results of a simultaneous variation of σ, α and β, table 6 presents the results of the variation of δ, ϵ and ν. The number of countries n ranges from 3 to 20; we include the results from 3 to 10. The pairs of numbers in the tables represent the stable

[10]The first number denotes the stable coalition size of coalition one – which is the Stackelberg leader in the game considered here – , the second number denotes the stable coalition size of coalition two.

coalition sizes.

Parameter			*Number of countries* $n=$						
δ	ν	ϵ	4	5	6	7	8	9	10
0.1	0.1-0.2	0.1-0.9	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.3	0.1-0.8	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
		0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.4-0.5	0.1-0.7	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
		0.8-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.6-0.7	0.1-0.6	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
		0.7-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
	0.8-0.9	0.1-0.5	(1,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
		0.6-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)
0.2-0.9	0.1-0.9	0.1-0.9	(2,2)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)	(2,3)

Table 6: *Stb-Stb.:* Multivariate sensitivity analysis over ϵ, ν, δ

If n exceeds four countries the results of the 'standard' equilibrium which are discussed above do not vary with the parameter values. Again, for $n = 4$ countries we have few cases where the stable coalition sizes are three and one rather than two and two. In short, these cases do occur in the same situations as discussed in the univariate analysis. The same reasoning applies here,too.

References

[1] Alesina, A. and V. Grilli, 1993, On the feasibility of a one- or multi-speed European Monetary Union, Discussion Paper Series 792, CEPR.

[2] Artis, M. J., Melitz, J. and M. Kohler, 1998, Trade and the number of OCAs in the world, Open economies review 9:S1, 537 – 567.

[3] Bayoumi, T. and B. Eichengreen, 1994, One money or many? Analysing the prospects for monetary unification in various parts of the world, Princeton Studies in International Finance 76, Princeton.

[4] Buiter, W. H., G. Corsetti, and P. A. Pesenti, 1995, A centre-periphery model of monetary coordination and exchange rate crises, Discussion Paper Series 1201, CEPR.

[5] Canzoneri, M. B., 1982, Exchange intervention policy in a multiple country world, Journal of International Economics 13, 267 – 289.

[6] Canzoneri, M. B. and J. A. Gray, 1985, Monetary policy games and the consequences of non-cooperative behavior, International Economic Review 26(3), 547 – 564.

[7] Canzoneri, M. B. and D. W. Henderson, 1991, Monetary policy in interdependent economies: A Game-theoretic approach (MIT Press).

[8] Casella, A., 1992, Participation in a currency union, American Economic Review 82(4), 847 – 863.

[9] D'Aspremont, C., A. Jacquemin, J. J. Gabszewicz, and J. A. Weymark, 1983, On the stability of collusive price leadership, Canadian Journal of Economics 16, 17–25.

[10] Hamada, K., 1976, A strategic analysis of monetary independence, Journal of Political Economy 84, 677–700.

[11] Kohler, M., 2002, Coalition formation in international monetary policy games, Journal of International Economics 56,371–385.

[12] Martin, P., 1995, Free-riding, convergence and two-speed monetary unification in Europe, European Economic Review 39, 1345 – 1364.

[13] Yi, S.-S., 1997, Stable coalition structures with externalities, Games and Economic Behaviour 20, 201–237.