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A COALITION-FORM ANALYSIS OF THE "ONE COUNTRY - ONE VOTE" RULE IN THE GOVERNING COUNCIL OF THE EUROPEAN CENTRAL BANK*

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This paper analyses the "one country – one vote" rule for monetary policy decision making of the Governing Council of the European Central Bank in a framework of co-operative game theory. The Shapley value is used as a solution concept. In contrast to former papers analysing the allocation of abstract "voting power" in committees of international organisations, preferences for monetary policy are modelled to obtain a prediction about potential transfers implied by an equal allocation of voting rights when countries are of different size. It is shown that if the number of countries participating to a currency union grows and the weight of the largest country within the currency union becomes small, the allocation of voting rights becomes irrelevant in the sense that transfers per country tend in any case to zero. [C71, E5, F02]

1. INTRODUCTION

Since the start of European Integration more than forty years ago, the division of rents from co-operation among Member States has been widely discussed. Especially the largest Member State in terms of population and GDP, Germany, raised its voice regularly in the last years claiming that the net transfers it would make to the European Union were disproportionate. Obviously, the division of rents from co-operation in any organisation is related to the voting mechanism and assignment of voting rights in the decision making committees of the organisation. The debate on transfer payments is therefore often associated to the debate on a "fair" representation of Member States in (or assignment of nomination rights for) the different relevant institutions (the Commission, the Parliament, and the Council of Ministers).[1]

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[1]See for instance Bindseil and Hantke (1997) for an analysis of the power distribution of

On 1 January 1999, a further important step towards an ever closer European integration was taken by launching Stage Three of European Monetary Union (EMU). The European Central Bank is now responsible for the single monetary policy in all participating EU Member States. This raises the question of how EMU may affect the general distribution of rents from co-operation in the European Union and hence transfer flows between member states.

The competencies to formulate the common monetary policy are assigned in the articles 10 to 12 of the "Protocol on the Statute of the European System of Central Banks and of the European Central Bank". Article 12 specifies that the Governing Council of the ECB (the "ECB Council") shall formulate the monetary policy of the Community. The composition of the ECB Council is specified in Article 10 of the Protocol: it "shall comprise the members of the Executive Board of the ECB and the Governors of the national central banks". The Executive Board, which is responsible for the implementation of the monetary policy in accordance with the guidelines laid down by the ECB-Council, "shall comprise the President, the Vice President and four other members." The Members of the Executive Board are chosen unanimously by the EU Council (Article 11.2). The allocation of voting rights in the ECB Council is specified in Article 10.2, second paragraph of the protocol. Accordingly, in all monetary policy decisions, *each member of the ECB-Council will have one vote and decisions will be taken by simple majority*. In case of a tie, the President of the ECB shall have the casting vote.

The implied equal allocation of voting rights among states of very different size (such as for instance Luxembourg and Germany) may be perceived as surprising. A motivation for it is reported by Thygesen (1990: 10-11):

> *"One point in which agreement has unexpectedly emerged in the preparations for the Intergovernmental Conference and which should reinforce this independence [of the ECB], is that each central bank governor will have one vote, as will the additional 5-6 members to be nominated for the Council at the European level. A system of weighted voting as in the Council of Ministers - or on the executive board of the IMF, including rules for blocking votes by minorities - would have fostered the thinking that the governors were just national representatives and not equal members of a collegiate body charged with formulating a common policy."*

But what are the implications of the adopted equal assignment of voting rights if the psychological effect described by Thygesen would not be effective, and members of the Governing Council would still focus on their home country? The present paper investigates the potential *distributional* consequences of the equal allocation of voting rights among member states of a monetary union such as EMU under the opposite assumption that the Governors of the National Central

Member States in EU decision making procedures.

Banks behave strictly as agents of their home country when acting in decision making in the ECB Council. This nationalistic scenario (which is probably not an adequate description of reality) provides a worst-case scenario in terms of any potential distributional implications of EMU. To be able to focus exclusively on the distributional implications, the paper assumes that decision making in the ECB Council always results in policy decisions which maximise the welfare of the whole monetary union and that the bargaining process in the ECB Council can be seen as a game in coalition form in which the bargaining outcome is determined by the formal bargaining structure and a solution concept as the Shapley value can be applied.

Two approaches can be found in the literature from which one could start developing a co-operative analysis of the allocation of voting rights in the ECB Council:

(1) The first approach starts from a concrete economic/monetary conflict of interest among participating countries. A corresponding strategic game is solved and the efficiency of the outcome is assessed whereby distributional aspects are then analysed more or less as a by-product, if at all. Examples of such approaches to EMU are Carraro (1990), Casella (1992), Alesina and Grilli (1992), von Hagen and Sueppel (1994), and Brueckner (1997).[2] In contrast, the present paper focusses exclusively on distributional aspects by assuming strictly efficient co-operation, which allows to apply the tools of coalition form analysis.

(2) The second approach consists in the coalition form analysis of the distribution of "power" in governing committees of International Organisations as first proposed by Shapley and Shubik (1954). No analysis of the distribution of power in the ECB Council based on this method can be found yet in the literature, which is probably due to the triviality of applying it to a Committee with such a simple decision making structure and allocation of voting rights as the ECB Council. By nature, an equal distribution of power is implied by such a setting, but it is not clear what we can really learn from that.

This paper develops a framework combining in a certain sense both approaches by deriving an expected Shapley value for the voting game in the ECB Council under the assumption of well-defined stochastic preferences of member states for monetary policy, and the inherent assumption of co-operative game theory that the efficient outcome is reached at the end of the bargaining process. Before proceeding, it is worth discussing in some more depth the three critical assumptions underlying the approach of this paper:

[2]The work by Brueckner (1997) is an exception in this literature since it explicitly integrates elements of co-operative game theory in his analysis. The approach adopted here is however more strict in assuming perfect efficiency of co-operation to be able to focus only on distributional aspects.

(*A*) *The assumption that the Shapley value is useful to predict the outcome of a voting game such as the monetary policy decision making of the ECB's Governing Council.*

The co-operative approach in game theory has sometimes been criticised for lacking strategic foundations and for being of an exclusively *normative* nature and therefore not suitable for making forecasts of the actual division of rents from a game (see for instance Ordeshook, 1986: 463). The claim that the co-operative approach lacks strategic foundations is no longer true at least for the Shapley value since Gul (1989) establishes a theorem in which the payoffs associated with efficient equilibria converge to the agents' Shapley values as time between periods of the dynamic game goes to zero.[3] With regard to the second criticism, this paper takes the view of for instance Luce and Raiffa (1957), Selten (1970), (1971) or Mas-Colell (1987) that the Shapley value is also a descriptive concept suitable to make predicitions about the distribution of rents in actual games and that it is not primarily a normative concept defining a "fair" distribution. Indeed, even though this question has not found too much attention in recent years, the claim that the Shapley value is a useful descriptive concept especially in the case of voting games has been sustained by various experimental results. Luce and Raiffa (1957: 268), reviewing the results of an experiment by Kalisch, Minor, Nash and Nering (1952) conclude that "actually, the [Shapley] value is not a bad indicator of a player's expectation". The problem of the predicitve power of solution concepts of co-operative game theory in voting games was reviewed in depth by Selten and Schuster (1970) and Selten (1972). The conclusion from their analysis of various experiments is that even though some questions remain, there can be no doubt that the Shapley value is also a descriptive concept and therefore of use to forecast the results of situations of strategic interactions that can be represented in coalition form.

(*B*) *The assumption of a national orientation of preferences of Governing Council members.*

It is not claimed here that this assumption is the best description of reality, but it is made to be able to analyse the implications that such nationalist preferences would have in a co-operative setting. In taking this assumption, the paper follows the tradition of work applying non-co-operative game theory to decision making in the ECB Governing Council (see above). It is not the intention here to discuss in detail how strong the nationalist bias of preferences of members of the Governing Council could be in reality. Just a few considerations: On the one hand, all members of the Governing Council are chosen by Governments, which

[3]Although it has to be noted that the characteristic function of the game modelled here does not fulfil all the assumptions made by Gul (1989).

have been elected by voters. Voters should vote for parties that have a reputation to act in their interest. In the case of the nomination of a member of the ECB Council, a Government would act in the interest of its voters if it chooses a person having a reputation of defending the interests of her or his home country. On the other side, the Statute of the European System of Central Banks specifies that members of the Governing Council are independent and that Governments shall not attempt to influence decision making in the ESCB.

(*C*) *The assumption of efficient co-operation in the ECB's Governing Council.*

If one assumes that members of the ECB's Governing Council have preferences determined only by the welfare of their home country, the assumption of an efficient co-operation between them is equivalent to the assumption that side payments between the players of the game are possible. However, it is important to note that this should not be understood as requiring that there are actual side-payments between the members of the Governing Council, i.e. within the ECB itself. The assumption of the possibility of side payments is more to be seen as a complement to the assumption that Governors of National Central Banks are guided by considerations regarding mainly the welfare of their home country. Under the extreme assumption that Governors act quasi as automata for their home country, the actual players of the game are in fact the participating EU countries, between which side-payments are rather plausible and possible for instance through the EU budget.[4]

The paper proceeds as follows: *Section 2* begins by a general characterisation of the "nature" of International Organisations (IOs) as incomplete contracts. Then the analysis of the expected distribution of rents from economic integration as a function of the allocation of voting rights is introduced. The decision making in the leading committee of an IO is modelled as a game in coalition form and the Shapley value is used as a solution concept for this game. To apply this framework to EMU, *Section 3* proposes a simple model of national preferences for monetary policy. Each participating country is characterised by an expectation-augmented Phillips-curve supply function and a loss function. *Section 4* applies the game theoretic framework exposed in section 2 to the case of a monetary union modelled in section 3 and in particular analyses the role of the number of countries participating to the currency union for the distributional relevance of the allocation of voting rights. It is shown that if the number of participants grows, the allocation of voting rights becomes less and less relevant in the sense that transfers per country tend in any case to zero. The application of this finding to EMU suggests that the "one country one vote" rule in monetary policy decision

[4]For a more detailed discussion of the approach to assume all representatives in EU institutions as representing strictly the interests of their country, see Bindseil and Hantke (1997: 173-174).

making is not to be considered problematic in the co-operative framework adopted here. *Section 5* draws conclusions.

2. THE DISTRIBUTION OF RENTS FROM INTERNATIONAL CO-OPERATION

In this section, the nature of IOs as well as the relationship between the allocation of voting rights between member states in the leading committee of an IO and the distribution of the rents arising from the co-operation governed by the IO are analysed.

A. The Nature of International Organisations

States can enhance the welfare of their citizens by international co-operation. For example, a free trade organisation or a monetary union allow for the realisation of rents from enhanced international specialisation. In most cases, co-operation has to be sustained by a *contract*, or as it is called in the international context, by a *treaty*. As has been remarked in the economic literature at least since Klein, Crawford and Alchian (1978), many real contracts are left implicitly or explicitly *incomplete*. The precise duties and rights of the contracting partners are not fully pre-specified for all possible future states of the world. The reason for the incompleteness is generally seen in the prohibitive costs of specifying in advance the contract for all relevant possible different states of the world (see for example Hart and Holmstroem (1987, 31)).

This is true for private contracts as well as for international treaties. The fact that nearly all long term treaties become once the source of a renegotiation, arbitration or litigation proves that the incompleteness of long term contracts is important for all but the simplest co-operation problems. In treaties conceived as complete but also in many other treaties left more or less explicitly incomplete, the renegotiation mechanisms are not explicitly defined. This differentiates them from another category of long term international treaties, namely *International Organisations*, where the incompleteness is very explicit in the fact that precise mechanisms to fill up the incompleteness are spelled out. Examples of such organisations for international co-operation are the NATO (governed by the NATO-Council and the Military Committee), the EU (governed by the Commission, the Council, and the European Parliament), the IMF (governed by the Council of Governors and an Executive Directorate), and also the *European Central Bank* governed by its Council. What Easterbrook & Fischel (1983, 401-402) remark concerning the private firm could be applied as well to any IO:

> *"In any undertaking of this nature, it is impossible to specify fully by contract the duties of and limitations on each actor. It is also inefficient to spell things out; the savings in*

contracting costs available by substituting continuing relations for detailed contracts are among the benefits of the firm... Something must fill in the details. Voting serves that function. The right to vote is the right to make all decisions not otherwise provided by contract..."

The division of rents as a function of procedural rules and the allocation of voting rights is one of the problems in the design of a constitution for a state, a firm, a private non-profit organisation, or an international organisation. It seems plausible that the constitution will influence the distribution of future rents from co-operation among the members of the organisation. In the phase of the founding of the organisation, when the "veil of ignorance" prevails, i.e. when the forms of co-operation and possible coalitions are still unknown, it is already possible to think about an expected future distribution of the rents arising from co-operation.

Why cannot European monetary integration be governed by a complete contract? Approaching the question from a non-international point of view, one can ask equivalently: why is monetary policy generally not specified in the form of a complete contract between the government (the citizens) and some executive agency responsible only for the application of an automatism? This is the well-known question of the "rules versus discretion" debate. The control of monetary policy by an everlasting rule is seen to be inefficient because of the impossibility of writing down a complete contract, which would not allow for additional rents from re-negotiation. The real world may be too complex to specify in advance a monetary contract integrating all contingencies into an optimal monetary policy function. Unexpected contingencies, can always emerge. "Discretion" means that the executive agency of monetary policy will not be bound by a complete contract, i.e. a precise monetary rule. In EMU, the discretion to formulate monetary policy was assigned to the ECB Council. Instead of looking for complicated relationships between the contingencies of the world and the optimal monetary policy to be implemented, only the composition of the committee, the means of the members to articulate their preferences and the mechanics of aggregation of the individual preferences had to be specified.

B. Analysis of the Distribution of "Power" in a Committee System

A precise way to formalise the structure of a multilateral bargaining problem is to take as starting point its *characteristic function*. Let N = {1,2,...|N|} be the set of players of the bargaining game. Let $S \in \wp(N)$ be a coalition of players ($\wp(N)$ is the set of all subsets of N). The characteristic function $v(S)$ assigns a number to each possible coalition of players S, which is the rent that this coalition is able to generate without the participants of the game that are not part of it.

One axiomatic solution concept for such games in coalition form is the *Shapley value* proposed by Shapley (1953). For a characteristic function v, it assigns to

each player $i \in N$ a number $f_i(v)$ which can be interpreted as the expected rent from participating to the game in coalition form v. Shapley (1953) required this mapping $f_i(v)$ to satisfy three axioms seen as plausible requirements.[5] Shapley proved that there is exactly one mapping f_i satisfying the three axioms, later called the Shapley value:

$$f_i(v) = \sum_{S \subseteq N-i} \frac{|S|!(|N| - |S| - 1)!}{|N|!} \left[v(S \cup \{i\}) - v(S) \right] \qquad (1)$$

The application of the Shapley value to political science was first undertaken by Shapley and Shubik (1954) as "A Method for Evaluating the Distribution of Power in a Committee System." The idea of Shapley and Shubik was to interpret the decision-making procedure in a committee as a game in coalition form. Voting games in committees can be interpreted as a special form of games in coalition form, namely as *simple games*. A simple game is a game in coalition form with a characteristic function for which holds that $v(N) = 1$ and $v(S)$ is either 1 or 0, for all S. Suppose there is some rent that can be realised by the voting of some committee. The *constitution* of the committee prescribes a certain majority condition for the passage of the decision that allows for the rent. Let N be the set of all the members in the committee holding some voting rights. Each coalition S of members either has the required majority to pass the law or not. If it has the majority, it can realise the rent in question, if it has not, it cannot. If the legislative rent is now normalised to 1, it is clear that the voting game can be seen as simple game where $v(S) = 1$ for each coalition S of committee members with enough votes to fulfil the required majority and $v(S) = 0$ for each coalition S without enough votes. For simple games, the marginal contribution $\left[v(S \cup \{i\}) - v(S) \right]$ is always either 1 or 0. Thus for voting games, the Shapley-Shubik index ("SSI") of a committee member i can be interpreted as the probability that this member is pivotal to a decision if all orderings of members are equally likely.

The application of the SSI to the ECB Council would lead to the evident conclusion that with |N| participating member states, the a priori quota of power of each would be $1/|N|$. If one would then further proceed as for example Widgren (1994) or Bindseil and Hantke (1997), one could compare this power quota with the number of inhabitants of the different participating Member States to conclude that per head, the power quota in the ECB Council is more than 200 times higher in Luxembourg than in Germany, which may be perceived as "unfair". But what is exactly to be understood under "the distribution of power" in the

[5]See for example Myerson (1991: 437) for a formal statement and the interpretation of the axioms.

committee obtained by applying the SSI to the ECB Council voting game? How does it relate to the expected distribution of rents from co-operation within the organisation? In the following section, the relation between voting power, preferences and the expected distribution of rents from co-operation is derived, using an actual Shapley value for voting games with defined preferences.

C. Analysis of the Distribution of Rents in a Committee System

Suppose that we have a set N of |N| countries which can benefit potentially from some economic integration. Let now $z \in Z$ be the policy variable controlled individually by each country before economic integration and collectively after. Let $u_i(z, x)$ be the utility or welfare function of country i, for $i = 1 \ldots |N|$. Let x be a vector of random variables representing the state of the world with the common probability distribution $f(x)$.[6] The analysis of the distribution of rents and of the transfer payments between the states participating in the economic integration involves four steps:

FIRST STEP: Suppose in the first three steps that a certain value of x has been drawn. First, the characteristic function of the game in coalition form has to be derived from the strategic voting game. For example Myerson (1991, 423-424) considers three methods for this: The *minimax representation*, the *defensive equilibrium representation*, and the *rational threats representation*. We will consider here only the *defensive equilibrium representation* which assumes a relatively "peaceful" behaviour of the players. Following Myerson (1991: 424), v is a defensive equilibrium representation of a strategic-form game with transferable utility, iff, for every pair of complementary coalitions S and N-S, there exist strategies $\bar{s}_S$ and $\bar{s}_{N\text{-}S}$ such that ($C(\Delta_S)$ is, $\forall S \subseteq N$ the set of available strategies of coalition S; $w_i(s_S,, s_{N\text{-}S})$ is the utility of player i if the strategies ($s_S,, s_{N\text{-}S}$) are played by the two complementary coalitions):

$$\bar{s}_S \in \arg\max_{s_S \in C(\Delta_S)} \left(\sum_{i \in S} w_i(s_S, \bar{s}_{N\text{-}S}) \right), \bar{s}_{N\text{-}S} \in \arg\max_{s_{N\text{-}S} \in C(\Delta_{N\text{-}S})} \left(\sum_{j \in N\text{-}S} w_j(\bar{s}_S, s_{N\text{-}S}) \right), v(S) = \sum_{i \in S} w_i(\bar{s}_S, \bar{s}_{N\text{-}S}), v(N - S) = \sum_{j \in N\text{-}S} w_i(\bar{s}_S, \bar{s}_{N\text{-}S}). \quad (2)$$

[6]The assumption is made that it cannot be refered to this vector of random variables in a contract written before the realization of this vector. This approach was first taken by Grossman and Hart (1986) and has been, since then, standard in the theory of incomplete contracts.

The expression $w_i(s_S, s_{N-S})$ in this definition corresponds in our specific problem of the voting for a policy parameter z in a certain economic environment x, to the function $u_i(z\ (s_S, s_{N-S}), x)$. In our case, the set of available strategies of all coalitions S included in N are identical. They consist of the possible values of the policy parameter $z \in Z$. The defensive equilibrium representation can thus be described simpler as follows:

If S is a winning coalition (and N-S is not winning), then:

$$\bar{z} \in \arg\max_{z \in Z} \sum_{i \in S} u_i(z, x)$$

If N-S is a winning coalition (and S is not winning), then:

$$\bar{z} \in \arg\max_{z \in Z} \sum_{j \in N-S} u_j(z, x)$$

The characteristic function is: $v(S) = \sum_{i \in S} u_i(\bar{z}, x)$, $v(N - S) = \sum_{j \in N-S} u_j(\bar{z}, x)$

To write the characteristic function in a compact way, define $a(S)$ as follows: $a(S) = 1$ if S is a winning coalition; $a(S) = 0$ if S is not a winning coalition. Suppose in addition that $\forall S \in N, \forall x,$ there is exactly one $\bar{z} \in Z$ which maximises $\sum_{i \in S} u_i(z, x)$ and that this *argmax* is a continuous function in x. We can now write the characteristic function $v(S)$ as follows:

$$\begin{aligned} v(S) &= a(S) \sum_{i \in S} u_i\left(\left[\arg\max_{z \in Z} \sum_{i \in S} u_i(z, x)\right], x\right) \\ &\quad + (1 - a(S)) \sum_{i \in S} u_i\left(\left[\arg\max_{z \in Z} \sum_{j \in N-S} u_j(z, x)\right], x\right) \\ &\Leftrightarrow v(S) = a(S) \operatorname*{Max}_{z \in Z} \sum_{i \in S} u_i(z, x) \\ &\quad + (1 - a(S)) \sum_{i \in S} u_i\left(\left[\arg\max_{z \in Z} \sum_{j \in N-S} u_j(z, x)\right], x\right) \end{aligned} \tag{3}$$

SECOND STEP: The Shapley value formula is applied to this characteristic function to derive the Shapley value.

THIRD STEP: From the Shapley value and the utilities of the players when no agreement is reached, we can deduce the *transfer vector* we can expect between the players. The welfare associated with the Shapley values is implemented through two channels, namely through the direct benefits associated with the adopted policy decision, and through the received or paid transfers. Therefore, the vector of received transfers must be calculated as the difference between the Shapley values and the welfare levels when adopting $z = z^* = \arg\max_{z \in Z} \sum_{i \in N} u_i(z, x)$. For i=1..n:

$$f_i(x) = t_i + u_i(z^*, x) \Leftrightarrow t_i = f_i(x) - u_i(z^*, x) \tag{4}$$

FOURTH STEP: We can now analyse the ex ante situation, i.e. the situation before the realisation of a vector of disturbances $x = (x_1, .., x_m)$. The expected value of the characteristic function, $E(v(S,x))$ can be written in the case of a continuous x, $f(x)$, $\forall S \subseteq N$:

$$E(v(S)) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \dots f(x)v(S,x)dx_1dx_2\dots dx_n \tag{5}$$

In the same way, the ex ante Shapley value of player *i* can be written, for all i=1...n:

$$E(f_i(x)) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \dots f(x)f_i(x)dx_1dx_2\dots dx_n \tag{6}$$

The ex ante vector of received transfers is:

$$E(t_i) = E(f_i(x)) - E(u_i(z^*, x)) \tag{7}$$

In the next section, this method for evaluating the transfer implications of the allocation of voting rights in a committee will be complemented by a minimalist model of national monetary preferences in a monetary union to finally make possible the analysis of potential transfer payments implied by a monetary union in section 4.

3. A SIMPLE MODEL OF NATIONAL MONETARY PREFERENCES

This section models a monetary union as a special example of an IO in which precise utility functions of the participating countries can be derived to obtain an ex ante distribution of the rents from co-operation.

A. National Preferences in a Monetary Union

Why should national preferences for monetary policy diverge in a monetary union? Three groups of reasons for this are distinguished here: (1) the shocks affecting the national economies are not necessarily perfectly correlated. For example, national strikes, fiscal policy shocks, or factor price movements affecting specific industries may have asymmetric implications for the national economies; (2) The mechanisms of transmission of monetary policy are not necessarily identical in all countries due to differences in the financial structure, the net wealth positions of different economic agents etc. Therefore, a certain amount of surprise inflation may induce different real effects in different countries; (3) The aversions against inflation may diverge in the sense that in some countries, a targeting of natural GNP at the expense of inflation variability is accepted while in others, price stability has absolute priority.

All three reasons for divergent national preferences for monetary policy are included in the following simple natural-rate model. The model is in the tradition of Barro and Gordon (1983) but does not consider for simplicity reasons an inflationary bias of monetary policy. It should be noted that any more complicated model of the transmission process in which monetary policy finally affects variables included in some welfare (loss) function could as well be used.

For each country, assume an expectation-augmented Phillips curve-supply function. Thus for i=1,...|N|: $Y_i = Y_i^* + b_i(p - p^e) + m_i$, where all variables are growth figures and b_i is a parameter describing the transmission mechanism and m_i is a random variable with a symmetrical density function, $E(m_i) = 0$ and $\mathrm{Var}(m_i) = s_i$. The second model component is a loss function for each country. For i=1,...|N|: $L_i = c_i(a_i p^2 + (Y_i - Y_i^*)^2)$. The parameter a_i expresses the aversion of the country *i* against inflation relative to its aversion against deviations of GNP form its natural value and c_i is a parameter for the country's size. By substituting the first equation into the second, we get the loss function (i=1,...|N|): $L_i = c_i (a_i p^2 + [b_i(p - p^e) + m_i]^2)$. Under rational expectations, the expected inflation rate p^e is always zero in this model, thus the loss function of country *i* can be simplified to (i=1,...|N|):

$$L_i = c_i(a_i p^2 + [b_i p + m_i]^2) \tag{8}$$

Now the *national* preferences for monetary policy in a given period, thus for a given realisation of m_i can be obtained by minimising the loss functions individually by choosing an adequate inflation rate p. One obtains the following preferred inflationary policies: $p_i^* = (-b_i)/(a_i + b_i^2)m_i$. The parameter for the size of the country, c_i, does not appear in this expression. The expected loss per period due to the macroeconomic disturbance m_i is, under the adoption of the optimal monetary policy (i=1...|N|): $E(L_i^*) = c_i a_i s_i^2 / (a_i + b_i^2)$. One obtains the overall period-wise expected loss due to the disturbances m_i under individual monetary policies in the whole potential currency union by simply summing up the |N| individual expected losses.

B. The Optimal Monetary Policy in a Monetary Union

Now the case of a monetary union with a common monetary policy and thus a common value of p in the whole area of the union is analysed. The overall loss function in a monetary union SL_{cmp} ("sum of losses, common monetary policy") is:

$$SL_{cmp} = \sum_{i=1}^{|N|} c_i \left[a_i p^2 + (Y_i - Y_i^*)^2 \right] \tag{9}$$

By substituting the supply functions under rational expectations, one obtains:

$$SL_{cmp} = \sum_{i=1}^{|N|} c_i \left[a_i p^2 + (b_i p + m_i)^2 \right] \tag{10}$$

By minimising this function, one obtains the optimal inflationary policy for a given realisation of the vector $u \in R^n$:

$$p^* = - \frac{\sum_{i=1}^{|N|} c_i b_i m_i}{\sum_{i=1}^{|N|} c_i (a_i + b_i^2)} \tag{11}$$

4. THE ROLE OF THE NUMBER OF PARTICIPANTS IN CASE OF LARGE DIFFERENCES IN THE SIZE OF PARTICIPATING COUNTRIES

In this section, the game theoretic tools exposed in section 2 will be applied to the model of a monetary union described in section 3. The focus of the analysis will be on the relevance of the number of participants in case of considerable differences in the size of participating countries (i.e. different weights in the welfare function of the entire currency area). For this purpose, the cases of a currency union with two, three, and four member countries will be reviewed subsequently. Then, a limit theorem will be derived that shows that if the number of participants to a currency area tends to infinity, the equal allocation of voting rights between small and large countries has no longer relevant consequences in distributional terms, since the expected transfers per large country tend to zero. Finally, to obtain an idea about the evolution of side payments when the number of participating countries increases, a simplified approach to their calculation is proposed that allows to derive the function mapping the number of participants into the size of side payments per participating large country.

In the entire section, the following specification will be assumed for the sake of simplicity: $\forall i = 1...|N|, a_i = 1;\ b_i = 1,$ i.e. the relative inflation aversion and the transmission mechanism are assumed to be identical in all countries, such that different preferences towards monetary policy stem only from different national shocks. Furthermore, it is assumed that there are only two types of countries in terms of size, namely large countries for which $c_i = 100$ ($i = 1, ..., m$) and very small countries for which $c_i = 0$ ($i = m + 1, ..., |N|$). The main focus in the following will be on the case that $m = |N| / 2$. Concerning the disturbances m_i, it is assumed that for i = 1,2 ...|N|: P(m_i = -2) = 0.5 and P(m_i = 2) = 0.5. Thus for i = 1, ..N $P(p_i^* = 1) = 0.5$ and $P(p_i^* = -1) = 0.5$. It is assumed that the shocks are independent in the |N| countries. Consider now the different cases one by one.

A. A Monetary Union with Two Participating Countries

Suppose that monetary policy decisions are taken by a committee (the central bank Council) in which each of the two participating countries has one vote and decisions are taken by simple majority, which is equivalent in this case to unanimity. Country 1 is the large country and country 2 the small one. Two different constellations of preferences are possible: with probability ½ both countries have the same preference and with the same probability they have opposite preferences for monetary policy. The optimal monetary policy in the monetary area will in any case be determined by the shock (the preferences) occurring in the large country since, by definition, the weight of the small country

in the welfare function of the monetary union is zero. In the case of adverse preferences, the characteristic function of the game would be v(1) = -400, v(2) = 0; v(1,2) = -200. In the case of identical preferences, we obtain in this specific case the same characteristic function, such that the ex ante characteristic function is also identical. Applying the Shapley value formula, we obtain:

$$f_1(v) = \frac{1}{2}(-400 - 0) + \frac{1}{2}(-200 - 0) = -300$$
$$f_2(v) = \frac{1}{2}(0 - 0) + \frac{1}{2}(-200 - (-400)) = 100 \qquad (12)$$

As the received transfers must be calculated, for i = 1,2 following: $t_i = f_i(x) - u_i(z^*, x)$, one obtains an expected vector of received transfers of (t_1, t_2) = (-300, 100) - (-200,0) = (-100, 100). This result is rather intuitive: half of the welfare gains that decision making in the Committee allows to the large country are transferred to the small one, such that both countries share the total rent equally.

Obviously, this outcome makes the monetary union rather unattractive for the large country. While the direct benefits of the monetary union (reduced transaction costs in trading with the other country, etc.) should be negligible in the large country, it has to share, after entering the monetary union, half of the rents generated by monetary policy decision making. The opposite is true for the small country: it should benefit much more from the direct advantages of the monetary union, and in addition now obtains large transfer payments from the large country to ensure its co-operation in monetary policy decision making. It is therefore unlikely that a large country would accept such a bilateral monetary union with a small country and an equal allocation of voting rights. The arrangement would be neutral in terms of transfers if the large country would be equipped with the entire voting power, e.g. would have two votes while the small country would have one. Then, it is however at all difficult to justify the monetary union, since the small country could as well follow mechanically all decisions of the large country without any formal arrangement. The fact that in the real world, most of the small countries peg their currency to a large country with which they have important economic relations seems to confirm this view. In such a case, the monetary policy is decided solely by the large country's central bank but the small country benefits from enhanced exterior stability. Our analysis therefore predicts the observed pattern that monetary unions (with an actual division of voting rights) are not formed when the weight of one country in the economic union would be very large.

B. A Monetary Union with Three Participating Countries

Assume that country 1 is large and countries two and three are small. With three countries, three different cases of preference constellations after the realisation of the monetary shocks have to be distinguished: First, the three countries can have identical preferences $p_i^* = -1$ for i = 1,2,3 or $p_i^* = 1$ for i = 1,2,3. Secondly, the two small countries can have the same preference being opposite to the one of the large country. Thirdly, the large country can have the same preference as one of the small countries while the other small country has the opposite preference. The probability of each constellation is 1/4, 1/4, 1/2, respectively. The monetary policy chosen will again be always the one that minimises the loss function of the large country alone. In the case of identical shocks in the three countries (implying homogeneous preferences), the characteristic function (under the defensive equilibrium representation) is: v(1) = -200; v(2) = 0; v(3) = 0; v(1,2) = -200; v(1,3) = -200; v(2,3) = 0; v(1,2,3) = -200. In the case that the two small countries have an identical shock and the large country has an adverse shock, the characteristic function takes the form: v(1) = -1000; v(2) = 0; v(3) = 0; v(1,2) = -200; v(1,3) = -200; v(2,3) = 0; v(1,2,3) = -200. In the third case in which the large country is subject to an identical shock as one of the small counties but an adverse shock relative to the other small country, the characteristic function is: v(1) = -400; v(2) = 0; v(3) = 0; v(1,2) = -200; v(1,3) = -200; v(2,3) = 0; v(1,2,3) = -200. The implied ex ante characteristic function is: E(v(1)) = -500; E(v(2)) = 0; E(v(3)) = 0; E(v(1,2)) = -200; E(v(1,3)) = -200; E(v(2,3)) = 0; E(v(1,2,3)) = -200. From this, the ex ante Shapley values (-300, 50, 50) and an expected transfer vector of (-100, 50, 50) can be calculated.

If countries 1 and 2 are both large and only country 3 is small, one obtains through similar calculations Shapley values of (-366.67, -366.67, 133.33) and transfer vectors of (-66.67, -66.67, 133.33).

In comparison to the two-country case, one may observe that adding of a small country does not increase the transfers to be paid by the large country. Adding a large country decreases the transfer to be paid by the original large country.

C. A Monetary Union with Four Participating Countries

The calculation of ex ante Shapley values and transfer vectors becomes already somewhat more tedious in the case of four countries since the number of different preference constellations increases to 16, the number of possible sub-coalitions to 24, etc. Therefore, this note does not calculate the exact Shapley values and transfers of currency unions with more than 4 members, but draws more general conclusions in the following subsections with the help of a limit theorem and a simplified method.

Table 1 below reproduces the transfer vectors implied by the different cases of

monetary unions with 4 participating countries. One result may be highlighted: the transfers in a currency union with two large and two small members are smaller than in the case of a currency union with one large and one small member, everything else being equal. On a first look, this appears surprising. However, there is a relatively obvious intuition behind this result: the more members the currency union has, the smaller is in general the influence of the large countries when they enter a coalition that needs just one more vote to become a winning coalition on the welfare maximising policy adopted by this coalition. Hence, as the formula of the Shapley value reveals, the more it will be able to appropriate of the decision making rent that emerges directly to it. The limit theorem in section 4.5 is based on this effect.

D. The Role of the Executive Board

In the previous subsections, the Governing Council of the federal central bank was specified as being composed exclusively of representatives of national central banks. But how can an "Executive Board" as the one of the ECB be integrated into the analysis? Three approaches seem to be possible:

- First, one may go back to the process of nomination of the members of the Executive Board and integrate this nomination process into the analysis of the voting mechanism. In the case of the ECB, the members of the Executive Board are nominated by consensus decision by the heads of Governments of Participating Member States. Therefore, the principle of equal weighting of votes of national representatives in the Governing Council is maintained for the nomination of the members of the Executive Board. One may conclude that, in an analysis of the transfer implications of an equal allocation of voting rights, one can thus simply ignore the existence of an Executive Board.
- Secondly, one can assume that the members of the Executive Board have preferences identical to the social welfare function of the entire currency area. However, to conduct a proper Shapley value analysis, weights of these preferences in the welfare function of each coalition would have to be specified, which does not really make sense. Only in the case of the two country currency union, one could assume that the member of the Executive Board has simply the same preferences as the large country, such that one could postulate that the Executive Board member is not a real player in itself but that the large country has just two votes. However, this interpretation is problematic for the case of more than one large country, since then, there may be conflicts of interest between these large countries.
- Thirdly, one might claim that in the case of the ECB, there is an implicit consensus that the members of the Executive Board should come from the large participating countries, even though this is not reflected formally in any

decision making rule. In this case, one could again ignore the members of the Executive Board as active players to apply the Shapley value framework developed above, and simply give two instead of one vote to the large countries. This can, in this third interpretation, be done consistently for any number of members of the currency union.

Even though it is argued here that the first approach is the strictest one in applying the general approach adopted in this note, it is of interest to consider what the alternative assumptions would imply in terms of transfers. The ex ante characteristic function in the case of a currency union with one large member with two votes and one small member with one vote is v(1) = -200, v(2) = 0, v(1,2) = (-200). Shapley values of (-200,0) are obtained, implying zero transfers. This is plausible in the special case of a two country monetary union, since doubling the votes of the large country implies that the large country always has a majority on its own.

In the case of a three country monetary union with one large country having two votes, one obtains Shapley values of (-250, 25, 25) and thus a relatively small transfer vector of (-50, 25, 25). Hence, unsurprisingly, increasing the votes of the large country (for instance through assuming members of the Executive Board to act as if they would provide such additional votes to large countries) reduces the transfer payments from large to small countries.

Table 1 . Implied transfers under various specifications of a small monetary union

	Transfer to be paid by large countries	Transfers received by small countries	Total transfer
|N|=2	-100	100	100
|N|=2, large country has two votes	0	0	0
|N|=3, one large two small	-100	50	100
|N|=3 two large, one small	-67	133	133
|N|=3 one large with 2 votes, two small	-50	25	50
|N|=4, one large, three small	-117	34	117
|N|=4, two large, two small	-83	83	167
|N|=4 three large, one small	-25	75	75

E. A Limit Theorem

The proposition in this section shows that in the case of federal organisations such as the monetary union modelled in section 3, the transfer payments per country that are likely to occur in case that members with rather different size are equipped with equal voting rights vanish if the number of participants tends to infinity and the weight of the large countries tends to zero. Therefore, the claim that an equal allocation of voting rights between countries of different size is problematic since it would trigger transfer payments becomes less and less relevant when the number of members of the organisation increases. For the proposition, define that the coalition $S \in \wp(N)$ is *just winning* if it can loose its property to be winning by loosing the vote(s) of one of its members.

PROPOSITION: *Assume that a set of |N| players N = {1,2.., |N|} plays a voting game with some well defined majority rule and an assignment of voting rights g(N), assigning to each player i a number of votes $g_i(N)$ to be used in simple majority voting. Assume also that when $|N| \to \infty$, the assignment of voting rights evolves in a way that,*

$$\forall i = 1...|N|: \ \lim_{|N|\to\infty} \frac{g_i(N)}{\sum_{i=1}^{|N|} g_i(N)} = 0 \tag{13}$$

Finally, assume that, for all coalitions S that are just winning and $\forall j = 1...|N|$:

$$\lim_{|N|\to\infty} \arg\max_z \sum_{i\in S} u_i(z) = \arg\max_z \sum_{i\in S-j} u_i(z) \tag{14}$$

Under these assumptions, the assignment of voting rights becomes less and less relevant when |N| becomes large in the sense that the distribution of the decision making rent does not depend any longer from the assignment of voting rights: for all g(N) satisfying the above mentioned property, and for all i, $\lim_{|N|\to\infty} t_i = 0$.

PROOF: Under the assumptions of the proposition, for any $g(N)$, for any $S \cup \{i\}$ which is just winning: $\lim_{n\to\infty}[v(S \cup \{i\}) - v(S)] = u_i(z^*)$. But then, if $n \to \infty$, the Shapley value formula will just yield $f_i(v) = u_i(z^*)$, and the transfer vector is

$t_i = f_i(v) - u_i(z^*) = 0.$ Q.E.D.[7]

The assumption about the vanishing of the share of votes of individual members when the number of members increases is obviously fulfilled for an equal allocation of voting rights. The second critical assumption, namely the one that when the number of participants increases, the impact of any player joining a coalition to make it a just winning coalition on the value of the policy parameter to be chosen by this coalition approaches zero, is also fulfilled since the weight of the large countries in the loss function of any coalition that is just winning vanishes when the number of members tends to infinity. Therefore, the limit theorem applies to our case of a monetary union as modelled in section 2.

F. A Simplified Method to Derive a Functional Relationship Between the Number of Participants and the Side Payments

The limit theorem exposed in the previous section leaves open the question of how rapidly the potential distributional implications of an equal allocation of voting rights between members of a currency union become negligible. The calculations for the case of a monetary union with up to four members made above suggested that the fall in transfers per large member is sizeable already when passing from two to four members. But what about a currency union with for instance 11 members such as the current euro area? To allow deriving a simple mapping between the number of participating countries to a currency union and the transfer payments per country, a simpler variant of the Shapley value analysis proposed in section 2 is developed here. Even though less directly based on the coalition form of the voting game, the method and results seem to be rather intuitive. The idea is to assume that the total expected voting rent is split, under an equal allocation of voting rights, equally between all participating members, such that each large country will simply have to transfer this total voting rent divided by $|N|$ (and each small country will receive exactly this transfer). Interestingly, in the case of our model of a monetary union, the expected total decision rent is independent of the number of participants, since the effect of the increased relevance of monetary policy decisions is exactly compensated by the decrease in the variance of the difference between the optimal and the default value of the policy parameter (the inflation rate). Indeed, as can be easily shown (see equation 11), the variance between the optimal inflation rate and the default rate is: $Var(p^* - 0) = 2/|N|$. The constant expected voting rent can be derived by calculating the expected value of the difference between the welfare functions (i.e. loss functions) under the optimal inflation rate and the default inflation rate (see

[7]I would like to thank an anonymous referee for having found a mistake in a previous version of the proposition and its proof and for having suggested an alternative proof similar to the one used above.

equation 10 and 11):

$$E\left(SL(p^*)- SL(0)\right)= E\left(\sum_{j=1}^{|N|/2}100\left[\left(\frac{\sum_{i=1}^{|N|/2}100m_i}{\sum_{i=1}^{|N|/2}200}\right)^2+\left(\left(\frac{\sum_{i=1}^{|N|/2}100m_i}{\sum_{i=1}^{|N|/2}200}\right)+m_j\right)^2\right]-\sum_{i=1}^{|N|/2}100m_j^2\right)$$

$$= E\left(\sum_{j=1}^{|N|/2}100\left[\left(\sum_{i=1}^{|N|/2}\frac{1}{|N|}m_i\right)^2+\left(\left(\sum_{i=1}^{|N|/2}\frac{1}{|N|}m_i\right)+m_j\right)^2\right]-\sum_{i=1}^{|N|/2}100m_j^2\right) \quad (15)$$

$$= 100\,E\left(|N|2\left(\sum_{i=1}^{|N|/2}\frac{1}{|N|}m_i\right)^2+2\sum_{j=1}^{|N|/2}\sum_{i=1}^{|N|/2}\frac{1}{|N|}m_im_j+\sum_{j=1}^{|N|/2}m_j^2-\sum_{j=1}^{|N|/2}m_j^2\right)$$

$$=\frac{200}{|N|}E\left(\sum_{i=1}^{|N|/2}\sum_{i=1}^{|N|/2}m_im_j+\sum_{j=1}^{|N|/2}\sum_{i=1}^{|N|/2}m_im_j\right)=\frac{200}{|N|}\left(\frac{|N|}{2}+\frac{|N|}{2}\right)=200$$

To obtain the last step, note that $\forall i = 1...|N|:\ E(m_i^2) = 4;\ \forall i \neq j:\ E(m_i m_j) = 0;$. Therefore, the average transfer per large country amounts simply to:

$$\forall i = 1...|N|/2:\ \ t_i = \frac{-200}{|N|} \quad (16)$$

Comparing this transfer function with the transfers displayed in Table 1 reveals that even though not identical, the differences are limited.[8] As expected, the transfers per country tend to zero when |N| grows without limits. However, the simplified formula furthermore gives an indication of the evolution of transfers when the number of members of the currency union goes for instance to 10.

[8]A noteworthy difference seems to be that the total transfers as indicated in table 1 grow when m = |N|/2 increases from 1 to 2. However, it should be noted that total transfers cannot grow beyond the total decision making rent, which is, as shown in equation (5), constant in the assumed central bank decision making problem.

Here, the transfers per country are 5 times smaller than in the case of a monetary union with 2 members.

One may conclude that the size effect in question is already rather important at the scale of a monetary union such as EMU. The "one member one vote" rule may be attractive for reasons that are not modelled in this note (see for instance the remarks by Thygesen (1990: 10-11) mentioned above or Brueckner (1998)). Therefore, it may well be the case that the transfers which the equal allocation of voting rights can imply are considered to outweigh its advantages in a small currency union of two or four members, but that the contrary is true for currency unions with 10 or more members.

It should be noted that this size effect does not occur when one applies the Shapley-Shubik Index (SSI) to this problem. In the framework of the SSI, it is not relevant whether *one* small and *one* large country or whether *ten* small and *ten* large countries form a currency union with an equal allocation of voting rights: the power quota per player differs between large and small countries by exactly the same coefficient in both cases. This shows how careful one must be to assume the SSI being equivalent to an application of the Shapley value to voting games.

6. CONCLUSIONS

In this paper, a coalition form analysis with the Shapley value as solution concept was applied to the decision making in the Governing Council of a monetary union. The approach went beyond the standard application of the Shapley-Shubik Index (SSI) to decision making in Committees, but consisted in the application of the actual Shapley value to a decision making problem with an underlying stochastic preference structure. The assumption of efficient co-operation inherent in a coalition-form analysis allowed focusing exclusively on transfer aspects. The required assumptions for such a co-operative analysis may appear to be strong, but even if they are not totally fulfilled in reality, the purely co-operative approach adopted here allows isolating and thereby better understanding effects, which certainly are at least of some relevance in the real decision making of organisations.

In the application of co-operative game-theory to a model of a monetary union, the note focused on the analysis of one feature of the monetary union, namely the number of participants. It was shown that in the case of a small monetary union with for example two or three members, conflicting national monetary interests could, together with an equal allocation of voting rights among member states of very different size, imply a pressure for transfer streams flowing from the large to the small countries. However, it could also be shown that the higher the number of participating countries, and thus the smaller the weight of the large countries in the total monetary area, the smaller became the transfers going from each large country to small countries that were implied by the equal allocation of voting rights. It was argued that this decline of transfers per country is so marked that

the conclusions to be drawn in terms of the net benefits of an equal allocation of voting rights are likely to be different for a monetary union with very few members as compared to one with for instance 10 or more members. In the case of a minimalist monetary union with two members, one may argue that the implied transfers from the large to the small country are unacceptably high and make the monetary union unattractive for the large country. In contrast, it seems that for big monetary unions, the advantages of an equal allocation of voting rights can easily outweigh the potential implied transfers from large to small countries. Fears that EMU will influence or intensify the transfer mechanisms within the European Union are therefore not well justified - even if preference of NCB Governors towards monetary policy would have a relevant national component.

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