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Abstract

This paper analyses the interaction between decisions on monetary policy in the future European Central Bank and different voting mechanisms. Using a simple stochastic model for preferences over monetary policy it is shown that the voting mechanism described in the actual statute leads to inefficient outcomes. The paper shows as well that the inefficiency can be resolved by allowing for sidepayments. The optimal monetary policy can be implemented by a noncooperative bargaining game. Moreover, by modifying the definition of the shares of the ECB, sidepayments can be introduced without drastically changing the institutional design of the ECB.

Keywords: European Monetary Union, voting, bargaining, Shapley value.

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1 Introduction

According to the Maastricht treaty some or all member states of the European Union (EU) will form an European Monetary Union (EMU) at the latest in 1999. The formulation of monetary policy will then be made by the Governing Council (Council) of the European Central Bank (ECB), which consists of the national central bank governors and the members of the Executive Board (Board). The primary objective of the ECB is to maintain price stability. A second objective is to support without prejudice to the primary goal the general economic policy in the EU. Since price stability and support of economic policy are not exactly defined, there will probably arise some conflicts over the optimal monetary policy between the members of the decisive Council. The treaty prescribes that such conflicts have to be resolved by voting among the members.

In this paper these conflicts arise from the fact that for different countries the optimal monetary policy will differ [for a detailed overview see Giovanetti and Marimon (1995)]. These conflicts can be about the concrete specification of price stability, e.g. due to fiscal disparities or different fiscal business cycles across countries, or about the choice of the optimal monetary instruments to achieve price stability, i.e. because of different monetary transmission mechanisms. The focus of the paper is on the consequences of conflicts over monetary policy within the Council and not on the origins of these conflicts.[1] Hence the optimal monetary policy will not be modelled explicitly. Instead I use a simple stochastic model for a N-country EMU where all countries are ex-ante symmetric with respect to their preferences over monetary policy. This enables a thorough investigation of the interaction between decisions and the allocation of voting weights within the Council. Since this paper analyses the situation for a given EMU, I neither address the normative question whether a EMU is pareto better compared to the status-quo of inde-

[1]The latter questions is investigated in detail in the literature on monetary integration, see e.g. de Grauwe (1994); for models taking polito-economical aspects into account see e.g. Alesina and Grilli (1992).

pendent national central banks[2] nor the positive question what kind of EMU would result from a bargaining process between different national countries[3].

One of the main questions that will be addressed regards the outcome of the decision-making process within the ECB in dependence on specific institutional characteristics. Moreover I will analyze the implications for efficiency and distribution across countries of this process and the relationship between efficiency and fairness considerations. Finally I want to answer how the actual statute of the ECB can be modified in order to achieve a pareto improvement. In general the decisions over monetary policy and the distribution of the benefits from it depend on the preferences of the countries, the underlying voting game and institutional characteristics, namely the possibility of making sidepayments. It will be shown that the voting mechanism influences the national benefits differently in an institutional setting with than in one without sidepayments.[4]

The paper proceeds as follows. In section 2 a framework which stylizes the future ECB will be set up. In section 3 the benchmark cases of jointly optimal decisions and fixed decision rules will be introduced. I will analyze in section 4 the decisions in the case that sidepayments are not possible. I will show that the expected welfare of a country in the EMU depends directly on his power in the voting game if power is measured by the Shapley-Shubik power index. On the basis of this result the optimal allocation of voting weights will be derived and compared with the benchmark cases and with alternative weights that focus on fairness instead of efficiency. Section 5 considers the outcome in the case that sidepayments are (without limits) possible. I will introduce a non-cooperative bargaining game among the national governors that implements the jointly optimal monetary policy. I will show that the sidepayments necessary for this implementation are a function of the distribution of voting weights in the voting game and the country specific

[2] This is done in the Optimal Currency Area literature, see e.g. de Grauwe (1994).

[3] For theoretical models see e.g. Casella (1992).

[4] The influence of voting on the benefits from monetary policy under a regime allowing for sidepayments is treated as well in Bindseil (1996).

optimal monetary policies. In section 6 I will discuss how sidepayments can be introduced into the ECB so that the jointly optimal policy can be implemented. The moderate change of the ECB statute I will propose enables sidepayments by changing the shares of the ECB. The proposal has the feature that the expected welfare of a nation is determined solely by the moments of the distribution of preferences over monetary policy. In section 7 an example for a likely future EMU is provided in order to illustrate the results of the previous sections. Section 8 concludes the paper.

2 General setting

Throughout this paper the ECB-Council is regarded as a collection of N player, who decide in every period t about a monetary policy $x_t \in X$ that is binding for every member. I take N as exogenously given, meaning that the decision about who joins the EMU is made. Moreover I assume that there is no possibility of leaving the EMU.

The preferences over monetary policy of the members $i \in N$ in period t, denoted by $x^*_{i,t}$, are assumed to be random variables. I make the following assumptions about their distribution.

$$x^*_{i,t} \text{ are i.i.d. across countries and time, } E\left(x^*_{i,t}\right) = 0,\ Var\left(x^*_{i,t}\right) = \sigma \tag{A1}$$

The values for the preferred monetary policy $x^*_{i,t}$ are the solution of the national welfare maximization problem with respect to x_t, i.e. $x^*_{i,t}$ is the optimal monetary policy for country i, taking into account the responses of all (national and foreign) agents to monetary policy and the fact that x_t is binding for all countries in the EMU. For simplicity I assume monetary policy to be one-dimensional, $X \subseteq \Re$. The easiest interpretation is that x_t is the inflation rate, but the analysis does not depend on the assumption that the ECB has complete control over inflation.[5]

[5]Even taking into account that the ECB has more than one instruments is in

The assumption $E\left(x_{i,t}^{*}\cdot x_{j,t}^{*}\right)=0,\quad i\neq j$, implies that countries face only idiosyncratic shocks in every period. The existence of additional common shocks would not alter the analysis substantially but make the expressions more complicated. The assumption $E\left(x_{i,t}^{*}\right)=E\left(x_{j,t}^{*}\right)\quad\forall i,j$ is crucial for the analysis. This can be justified since the EMU should be founded by countries that have a similar structure. Especially the convergence of inflation rates in all likely participants in the EMU and the fact that, unlike in the past, all national governors will be politically independent, might indicate that systematic conflicts over monetary policy are not likely to occur in the ECB. $E\left(x_{i,t}^{*}\right)=0$ is made just for convenience.

The utility function of a player $i\in N$ is given by

$$U_{i,t}=-\left(x_{i,t}^{*}-x_{t}\right)^{2}\tag{A2}$$

The welfare of a country is given by

$$W_{i,t}=\gamma_{i}\cdot U_{i,t},\quad\sum_{i\in N}\gamma_{i}=1,\quad\gamma_{1}<\gamma_{2}<...<\gamma_{n}.\tag{A3}$$

Moreover I use the following simple (European) welfare function:

$$W_{t}=\sum_{i\in N}W_{i,t}=\sum_{i\in N}-\gamma_{i}\left(x_{i,t}^{*}-x_{t}\right)^{2}.\tag{A4}$$

The utility function of a governor can be interpreted as a reduced loss function (multiplied by -1) arising from the fact that the joint monetary policy is not (necessarily) equal to the individually optimal one. National welfare is simply the individual utility of the governor multiplied with γ_i. The factors γ_i are importance measures reflecting that monetary policy is likely to be more important for bigger countries (e.g. since more people and/or more economic activity are affected). The assumptions about the normalization of γ_i and the ordering of N according to importance are just made for convenience. Hence $(A2)$ and $(A3)$ imply that national governors behave as if they aim to maximize the welfare of their countries.

principle no problem. If we had m instruments z^j, $\mathbf{z}_t=\left(z_t^1,...,z_t^m\right)\subseteq Z^m$, then x_t would be the result of a mapping $h:Z^m\rightarrow X$, i.e. $x_t=h\left(\mathbf{z}_t\right)$.

The way how the governors are chosen lies outside our analysis. Since the utility functions are time-separable and the optimal monetary policy is time-independent, the governor might represent the interests of the mean or the median in his country.[6] A shortcoming of these specifications of the utility and national welfare functions is that they allow no comparative analysis between different sizes of the ECB since the benefits of forming a EMU are not included in $(A2)$ and $(A3)$.

Regarding the informational structure I assume

$$x^*_{i,t} \text{ are common knowledge among all players in period } t. \tag{A5}$$

$(A5)$ becomes crucial in section 5 but could be relaxed in section 4. This assumption can be justified if we recall that $x^*_{i,t}$ depends on the actual data and the parameters of the correct (politico) macroeconomic model of each country. Common knowledge about economic data is a plausible assumption and the parameters of the underlying economic model can in principle be estimated by everyone.

The voting game within the ECB-Council is characterized by $(d, \mathbf{w})$. The vector of voting weights (or simple the votes) $\mathbf{w} = (w_1, w_2, ...w_n)$ is fixed over time, but can be chosen in the beginning. The value of d gives the decision (majority) rule, i.e. the minimum number of votes required for a majority. The coalitional (or characteristic) function, i.e. the function $v : 2^N \to \Re$ that assigns to every coalition $S \subseteq N$ a value as its worth, of a voting game is given by

$$v(S) = \begin{cases} 1 \text{ if } w_S = \sum\limits_{i \in S} w_i \geq d \\ 0 \text{ if } w_S = \sum\limits_{i \in S} w_i < d \end{cases}.$$

For the voting game I make the assumption that it is constant-sum in its coalitional function, i.e.

$$(v(S) = 1) \Leftrightarrow (v(N \backslash S) = 0)\,, \text{ or } \qquad (w_S \geq d) \Leftrightarrow (w_{N \backslash S} < d) \tag{A6}$$

[6] If we would relax the assumption $E\left(x^*_{i,t} \cdot x^*_{i,t-1}\right) = 0$, it might be beneficial for a country to select a more conservative governor [following Rogoff(1985)].

This assumption always holds if d is the simple majority rule and there is no possibility of a tie.[7]

The assumptions imply that every country has effectively one player in the voting game. At a first glance this feature seems a bit at odd with the actual ECB statute. According to the statute the Council consists of the national governors and the members of the ECB-Board. It is difficult to make assumptions about the preferences of the latter, especially if it is taken into account that they are elected unanimously by the EU-Council. There are some justifications for the simplification of not regarding the members of the Board explicitly. First, it might be assumed that the members of the board have the same utility function as the governor of their country of origin.[8] This implies that countries with members in the Board have accordingly more voting weights. Another possibility is to assume that the Board members have no specific preferences over monetary policy and hence abstain from voting (and abstention are not counted in the voting game). A third justification could be that the statute might be changed such the board members have no voting rights in the Council.[9]

A general feature of this framework is that no member of the Council cares directly for the welfare of the EMU as a whole. In my view this is a consequence of the EMU being a confederate system where the outcomes will probably be evaluated by the agents on the basis of the economic situation in their home country. Since the basic concern of the EMU should be the utility of the individuals in the different countries, the leading role of national interests in the decision making of the ECB

[7]Formally we could replace $(A1)$ by

$$\left(d = \begin{cases} \frac{w_N}{2} + 1 \text{ if } w_N \text{ is even} \\ \frac{w_N}{2} + \frac{1}{2} \text{ if } w_N \text{ is odd} \end{cases}\right) \wedge \left(\nexists S \mid w_S = w_{S \setminus N}\right)$$

[8]This view is expressed e.g. in Alesina and Grilli (1992).

[9]A strict seperation of formulating monetary policy (done by the Council) and its execution (by the Board) can be justified by applying fairness criteria, see Brueckner (1996).

is not only unavoidable but also no principal weakness of the system.

3 Two benchmark cases

A main concern of this paper is to analyze the dependence of the decisions made in the ECB-Council from the distribution of voting weights. Since the voting weights are chosen in the beginning, we analyze the outcomes in terms of expected national and European expected welfare. It follows directly from $(A1)$-$(A5)$ that

$$E(W_{i,t}) = E\left(-\gamma_i \left(x_{i,t}^* - x_t\right)^2\right) = -\gamma_i \left(\sigma + E\left(x_t^2\right) - 2E\left(x_{i,t}^* \cdot x_t\right)\right) \quad (1)$$

$$E(W_t) = E\left(\sum_{i \in N} W_{i,t}\right) = -\left(\sigma + E\left(x_t^2\right) - 2\sum_{i \in N} \gamma_i E\left(x_{i,t}^* \cdot x_t\right)\right) \quad (2)$$

Now I consider two benchmark cases in order to evaluate the different welfare results of voting mechanisms.

The first case is the one of jointly optimal decisions. The following proposition is straightforward:

Proposition 1 $x_t^* = \sum_{i \in N} \gamma_i x_{i,t}^*$. *Hence the joint optimal policy is the weighted mean of the individual optimal policies with the importance measures as weights.*

Proof. $W_t = \sum_i -\gamma_i \left(x_{i,t}^* - x_t\right)^2$. The F.O.C. of $\max_{x_t} W_t$ are

$$\frac{\partial W_t}{\partial x_t} = \sum_i 2\gamma_i \left(x_{i,t}^* - x_t\right) = 0$$

$$\Leftrightarrow \sum_i \gamma_i x_{i,t}^* = \sum_i \gamma_i x_t \Leftrightarrow x_t = \sum_i \gamma_i x_{i,t}^*$$

Since W_t is concave in x_t the second order condition is fulfilled. ■

In this case we have

$$E\left(x_t^2\right) = E\left(\left(\sum_{i\in N}\gamma_i x_{i,t}^*\right)^2\right) \tag{3}$$

$$= E\left(\sum_i \gamma_i^2 \cdot x_{i,t}^{*2} + 2\sum_i\sum_{j\neq i}\gamma_i\gamma_j x_{i,t}^* x_{j,t}^*\right) = \sigma\sum_i \gamma_i^2$$

$$E\left(x_{i,t}^* x_t\right) = E\left(x_{i,t}^*\left(\sum_{i\in N}\gamma_i x_{i,t}^*\right)\right) \tag{4}$$

$$= E\left(\gamma_i x_{i,t}^{*2} + \sum_{j\neq i}\gamma_j x_{i,t}^* x_{j,t}^*\right) = \sigma\gamma_i$$

Hence we get from (1) and (2) [10]

$$E\left(W_{i,t}^*\right) = -\gamma_i\left(\sigma + \sigma\sum_{i\in N}\gamma_i^2 - 2\sigma\gamma_i\right) \tag{5}$$

$$= -\sigma\left(\gamma_i + \gamma_i\sum_{i\in N}\gamma_i^2 - 2\gamma_i^2\right) \tag{6}$$

$$E\left(W_t^*\right) = -\left(\sigma + \sigma\sum_{i\in N}\gamma_i^2 - 2\sigma\sum_i\gamma_i^2\right) = -\sigma\left(1 - \sum_{i\in N}\gamma_i^2\right) \tag{7}$$

The second benchmark is that of a fixed monetary policy in each period. For the optimal fixed monetary policy x_t^f I make the following proposition.

Proposition 2 $x_t^f = E\left(x_{i,t}^*\right) = 0 \quad \forall t$ *is the optimal fixed monetary policy.*

Proof. Since the fixed rule by definition has to be chosen in the beginning, the problem is

$$x_t^f = \max_{x_t} E\left(W_t\right) \quad \forall t$$

[10] Note that the variance of the jointly optimal monetary policy is lower than the individually optimal ones since $\sum_{i\in N}\gamma_i^2 < 1$.

$$\text{or, using (2)}, \quad x_t^f = \max_{x_t} - \left(\sigma + E\left(x_t^2\right) - 2\sum_{i\in N}\gamma_i E\left(x_{i,t}^* \cdot x_t\right)\right)$$
$$= \max_{x_t} - \left(\sigma + x_t^2 - 2\sum_{i\in N}\gamma_i x_t E\left(x_{i,t}^*\right)\right)$$
$$= \min_{x_t} \sigma + x_t^2$$
$$\Rightarrow x_t^f = 0 \qquad \blacksquare$$

For this case we get from (1) and (2)

$$E\left(W_{i,t}^f\right) = -\gamma_i\sigma, \qquad E\left(W_t^f\right) = -\sigma \tag{8}$$

If we compare the benchmarks cases we have

$$E\left(W_t^f\right) < E\left(W_t^*\right), \qquad E\left(W_{i,t}^f\right) \lesseqgtr E\left(W_{i,t}^*\right) \quad \text{if} \quad \sum_{i\in N}\gamma_i^2 - 2\gamma_i \lesseqgtr 0.$$

Since the fixed monetary policy is almost surely different from the jointly optimal, it yields strictly lower European welfare. From their individual point of view, the small countries (those with $\gamma_i < \frac{1}{2}\sum_{i\in N}\gamma_i^2$) would be better off under the fixed rule.

4 No sidepayments

In this section I assume that no sidepayments among the members of the ECB Council are possible, neither within nor between periods. The voting procedure is described as follows. Every member has the right to propose a monetary policy x_t. If a majority (in the voting game) votes for this proposal, it is accepted. Otherwise it is rejected and again every player has the right to make a proposal. In this situation the median voter theorem applies, i.e. the chosen monetary policy of the ECB will be the optimal one for the median voter.

Proposition 3 *In an EMU without sidepayments and satisfying* $(A1)$-$(A6)$ *we get* $x_t = x^*_{m,t} \quad \forall t.$[11]

Proof. See Appendix. It is simply a proof of the standard median voter theorem applied to this model. ■

A voting equilibrium in the ECB is a pair $(x_t; \mathbf{a}_t)$, $\mathbf{a}_t = (a_{1,t}, ... a_{n,t})$, $a_{i,t} \in (yes, no)$ with $\sum_{i:a_{i,t}=yes} w_i \geq d$. It follows directly from proposition 3 that in any equilibrium $x_t = x^*_{m,t}$. If we assume (infinitesimal small) bargaining costs, equilibria always exist and $x_t = x^*_{m,t}$ will be proposed immediately. Obviously there are many equilibria since many vectors $\mathbf{a}_t$ fulfill the majority criterium, but they all share the same monetary policy. There is a unique equilibrium in not weakly dominated strategies that is characterized by $a_{i,t} = yes \quad \forall i$. Since in equilibrium $x_t = x^*_{m,t}$, voting $a_{i,t} = no$ either does not change the outcome or (if a majority votes *no*) leads to a new bargaining round yielding a lower pay-off since $x_t = x^*_{m,t}$ is agreed on later.

In the case without sidepayments we get

$$E\left(x_t^2\right) = E\left(x_{m,t}^{*2}\right) = \sigma \tag{9}$$

$$E\left(x^*_{i,t} \cdot x_t\right) = \phi_i \cdot E\left(x_{i,t}^{*2}\right) + \sum_{j \neq i} \phi_j \cdot E\left(x^*_{i,t} \cdot x^*_{j,t}\right) = \phi_i \sigma \quad , \tag{10}$$

where ϕ_i is the probability that i is the median. Inserting (9) and (10) into (1) and (2) yields

$$E\left(W_{i,t}\right) = -2\gamma_i \sigma \left(1 - \phi_i\right) \tag{11}$$

$$E\left(W_t\right) = -2\sigma \sum_i \gamma_i \left(1 - \phi_i\right) = -2\sigma \left(1 - \sum_i \gamma_i \cdot \phi_i\right) \tag{12}$$

[11] The assumption of common knowledge $(A5)$ can be replaced by the assumption that every governor i knows only $x^*_{i,t}$ if we add an announcement stage before the voting procedure. The strategy-proofness of median voter schemes ensures that the announced $x^*_{i,t}$ are their true values. The announcement stage simply avoids potentially time consuming pairwise voting procedures among all alternatives in the absence of perfect information.

Giving $(A1)$ the probability ϕ_i is solely determined by the voting game $(d, \mathbf{w})$. More precisely, we can make the following lemma:

Lemma 1 *The probability of being the median voter is exactly the Shapley-Shubik (1954) value in the voting game, i.e.*

$$\phi_i = \phi_i(d, \mathbf{w}) = \sum_{S \ni i} \frac{(s-1)!\,(n-s)!}{n!} \left[v(S) - v(S \backslash i)\right], \qquad (13)$$

where $s = |S|$.[12]

Proof. The definition of the median voter (33) implies that

$$[v(S) - v(S \backslash i)] = \begin{cases} 1 \text{ if } i = m \\ 0 \text{ if } i \neq m \end{cases}$$

Under $(A1)$ every ordering of the players according to their realization of $x^*_{i,t}$ has the equal probability $\frac{1}{n!}$. Denote the set of players with preferences 'left' resp. 'right' of player i with

$$L_i = \left\{ j \mid x^*_{j,t} \leq x^*_{i,t}, \quad j \neq i \right\}, \quad R_i = \left\{ j \mid x^*_{j,t} \geq x^*_{i,t}, \quad j \neq i \right\}$$

Let $S = L_i \cup i$. There are $(s-1)!$ possible orderings of the players $j \in L_i$ and $(n-s)!$ possible orderings of the players $k \in R_i$. Hence

$$prob\left(\left(x^*_{j,t} < x^*_{i,t} \quad \forall j \in L_i\right) \wedge \left(x^*_{k,t} > x^*_{i,t} \quad \forall k \in R_i\right)\right) = \frac{(s-1)!\,(n-s)!}{n!} \qquad (14)$$

Summing these probabilities over all sets L_i where $i = m$ gives then the probability of i being the median voter. [13] ■

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[12] In formula (13) I use $S \backslash i$ instead of $S \backslash \{i\}$. In the following I will replace $\{i\}$ by i whenever the context makes clear that a coalition is meant.

[13] Note that the Shapley-Shubik index is defined for games with transferable utility (TU games), while we are considering a game with non-transferable utility (NTU game). It could easily be shown that the Shapley-Shubik index equals the consistent (Shapley) value for NTU games defined by Maschler and Owen (1989) for hyperplane games if we let

$$V(S) = \begin{cases} y \in R^s : \sum_{i \in S} y_i \leq 1 \text{ if } w_S \geq d \\ 0^S \qquad\qquad\qquad \text{if } w_S < d \end{cases}$$

Hence it might be more appropriate to interprete the Shapley-Shubik index as a special case of the consistent value than as a special case of the ordinary Shapley(1953) value.

If we want to achieve the most efficient outcome given that side-payments are prohibited, that the decision is made in every period t and that the voting weights have to be chosen in the beginning (in period 0), we have to maximize $E(W_t)$ with respect to the voting weights $\mathbf{w}$.

Proposition 4 *$\phi_n^e = 1, \quad \phi_i^e = 0 \quad \forall i \neq n$ maximizes $E(W_t)$ if no sidepayments are possible. This is feasible with any allocation of voting weights $\mathbf{w}^e$ satisfying $w_n^e > d$.*

Proof. Consider an allocation of voting weights $\mathbf{w}'$ yielding
$\hat{\phi}_n = 1 - \Delta, \quad \hat{\phi}_j = \Delta, \quad \hat{\phi}_i = 0 \quad \forall i \neq n, j, \qquad \Delta \in (0,1]$. We have

$$\begin{aligned}
& E(W_t(\phi^e)) - E\left(W_t\left(\hat{\phi}\right)\right) \\
= & \left[E(W_{n,t}(\phi^e)) - E\left(W_{n,t}\left(\hat{\phi}\right)\right)\right] + \left[E(W_{j,t}(\phi^e)) - E\left(W_{j,t}\left(\hat{\phi}\right)\right)\right] \\
= & \left[0 + 2\sigma\gamma_n(1-(1-\Delta))\right] + \left[-2\sigma\gamma_j + 2\sigma\gamma_j(1-\Delta)\right] \\
= & 2\sigma\gamma_n\Delta - 2\sigma\gamma_j\Delta = 2\sigma\Delta(\gamma_n - \gamma_j) > 0 \quad \forall\, \Delta \text{ because } \quad \gamma_n > \gamma_j.
\end{aligned}$$

$(w_n^e > d) \Rightarrow (\phi_n^e = 1)$ follows directly from the definition of the Shapley-Shubik value. We have $v(S) - v(S \backslash n) = 1 \quad \forall S \ni n$ and $v(S) - v(S \backslash i) = 0 \quad \forall S \ni i, i \neq n$. Hence we get in this case $\phi_n^e = \sum_{S \ni n} \frac{(s-1)!(n-s)!}{n!} = 1$ and $\phi_i^e = 0 \quad \forall i \neq n$ ■

This implies that if we are interested only in European welfare, all the power should be given to the most important country (measured in terms of γ_i). For the expected utility of the countries and the expected (European) welfare we get in this solution:

$$E\left(W_{i,t}^e\right) = \begin{cases} 0 & if \quad i = n \\ -2\sigma\gamma_i & if \quad i \neq n \end{cases} \tag{15}$$

$$E\left(W_t^e\right) = -2\sigma(1-\gamma_n) \tag{16}$$

If we take the Maastricht treaty in his existing form as point of departure this solution might still be feasible for a EMU7. The treaty mentions no sidepayments, gives one vote for each governor for the most important decisions and allows for 6 members of the board. Thus if Germany as the biggest country could send all members of the Board and would select agents with identical utility function as the German governor, we would get the most efficient outcome under the constraint that sidepayments are not feasible. But most likely this would not be enforceable in the EU Council that decides on the members of the Board. Moreover we will see in the subsequent sections that solutions yielding higher expected welfare are implementable.

If we are interested in voting allocation yielding fair results, we have to specify fairness. One possibility is the fairness postulate that the share of expected utility of country to the expected European welfare should equal its importance measure, i.e. $\frac{E(W_{i,t})}{E(W_t)} = \gamma_i$. This specification of fairness can be called fair distribution of benefits.

Proposition 5 $\phi_i^b = \frac{1}{n}$ *gives a fair distribution of benefits. One possible allocation of voting weights guaranteeing this is* $w_i^b = 1$.

Proof. $\frac{E(W_{i,t})}{E(W_t)} = \gamma_i \Leftrightarrow \frac{-2\sigma\gamma_i\left(1-\phi_i^b\right)}{-2\sigma\left(1-\sum\gamma_i\phi_i^b\right)} = \gamma_i$

$\Leftrightarrow 1-\phi_i^b = 1-\sum\gamma_i\phi_i^b \Leftrightarrow \phi_i^b = \sum\gamma_i\phi_i^b \Rightarrow \phi_i^b = \frac{1}{n}$.

And $w_i^b = 1 \Rightarrow \phi_i^b = \frac{1}{n}$ since the Shapley-Shubik value fulfills the symmetry axiom $w_i = w_j \Rightarrow \phi_i = \phi_j$. ■

Inserting this result into (11) and (12) gives

$$E\left(W_{i,t}^b\right) = -2\sigma\gamma_i\left(1-\frac{1}{n}\right) \quad (17)$$

$$E\left(W_t^b\right) = -2\sigma\left(1-\frac{1}{n}\right) \quad (18)$$

Hence taking the voting distribution laid down in the Maastricht treaty is one possible way of getting a fair distribution of benefits if we could ensure that the members of the board abstain from voting and that abstentions are not counted for the majority rule.

Another possible fairness specification is to require a fair distribution of power in the sense that the probability of being the median equals the importance of a player, i.e. $\phi_i^p = \gamma_i$. Since $\boldsymbol{\phi}$ is not continuous in $\mathbf{w}$, $\phi_i^p = \gamma_i$ might not be feasible if we use a fixed decision rule like simple majority. But by using a measurable fairness criterium one can choose $\mathbf{w}^p$ to get the most fair distribution of power, see Brueckner (1996) for a formalization and application to the ECB.

Supposed $\phi_i^p = \gamma_i$ is feasible, we get in this case directly from (11) and (12)

$$E\left(W_{i,t}^p\right) = -2\sigma\gamma_i\left(1-\gamma_i\right) \tag{19}$$

$$E\left(W_t^p\right) = -2\sigma\left(1-\sum_i \gamma_i^2\right) \tag{20}$$

If we compare these three different voting distributions $\mathbf{w}^e, \mathbf{w}^b$ and $\mathbf{w}^p$ with respect to efficiency, we can make the following corollary.

Corollary 1 $E\left(W_t^e\right) > E\left(W_t^p\right) > EW_t^b$

Proof. $E\left(W_t^e\right) > E\left(W_t^p\right)$ follows directly from proposition 4.

The proof of $E\left(W_t^p\right) > EW_t^b$ runs the same arguments than the proof of proposition 4. Moving from $\mathbf{w}^p$ to $\mathbf{w}^b$ means redistributing power from the players with $\gamma_i > \frac{1}{n} = \bar{\gamma}$ to those with $\gamma_i < \frac{1}{n}$. And the increase of utility of the small players is lower than the decrease of utility for the big players since $\frac{\partial E(W_{i,t})}{\partial \phi_i} = 2\sigma\gamma_i$. ■

If we compare the expected welfare from using this three different voting weight distribution with our benchmark cases, i.e. if we compare (16), (18) and (20) with (7) and (8), we can make the following corollary:

Corollary 2 $E\left(W_t^*\right) > E\left(W_t^e\right)$, $E\left(W_t^f\right) > E\left(W_t^e\right)$ *if* $\gamma_n < \frac{1}{2}$,

$$E\left(W_t^f\right) > E\left(W_t^p\right) \text{ if } \sum_i \gamma_i^2 < \tfrac{1}{2} \text{and } E\left(W_t^f\right) > E\left(W_t^b\right) \text{ if } n > 2.$$

Proof. $\left(E\left(W_t^*\right) > E\left(W_t^e\right)\right) \Leftrightarrow \left(\left(2-\gamma_n\right) > \left(1-\sum_i \gamma_i^2\right)\right)$

$\Rightarrow \left(\left(2-\gamma_n\right) > \left(1-\gamma_n^2\right)\right) \Leftrightarrow \left(1 > \gamma_n\left(1-\gamma_n\right)\right)$.

The latter always holds since $\gamma_n < 1$.

The other three relationships follow immediately from comparing the values of expected welfare. ■

From these two corollaries it follows that expected welfare is strictly higher if the joint optimal decision could be implemented. If we take e.g. the intermediate case of a vote distribution $\mathbf{w}^p$ the expected welfare loss in the case of no sidepayments is twice as high as in the social optimum. And as long as the biggest country is not assumed to be more important than all the other together, even the introduction of a fixed monetary rule would always improve welfare.

Comparing the three voting weight distributions with the benchmark cases leads to the following corollary

Corollary 3 *For $i = n$ we have*

$$\begin{aligned} E\left(W_{i,t}^e\right) &> E\left(W_{i,t}^p\right) > E\left(W_{i,t}^b\right), E\left(W_{i,t}^e\right) > E\left(W_{i,t}^*\right), \\ E\left(W_{i,t}^e\right) &> E\left(W_{i,t}^f\right), E\left(W_{i,t}^*\right) > E\left(W_{i,t}^p\right), E\left(W_{i,t}^f\right) > E\left(W_{i,t}^p\right), \end{aligned}$$

for $i \neq n, \gamma_i > \frac{1}{n}$

$$E\left(W_{i,t}^p\right) > E\left(W_{i,t}^b\right) > E\left(W_{i,t}^e\right), E\left(W_{i,t}^*\right) > E\left(W_{i,t}^p\right), E\left(W_{i,t}^f\right) > E\left(W_{i,t}^p\right),$$

for $i \neq n, \gamma_i = \frac{1}{n}$

$$E\left(W_{i,t}^p\right) = E\left(W_{i,t}^b\right) > E\left(W_{i,t}^e\right), E\left(W_{i,t}^*\right) > E\left(W_{i,t}^p\right), E\left(W_{i,t}^f\right) > E\left(W_{i,t}^p\right)$$

and for $i \neq n, \gamma_i < \frac{1}{n}$ we have

$$\begin{aligned} E\left(W_{i,t}^b\right) &> E\left(W_{i,t}^p\right) > E\left(W_{i,t}^e\right), E\left(W_{i,t}^f\right) > E\left(W_{i,t}^b\right) \\ E\left(W_{i,t}^*\right) &> E\left(W_{i,t}^b\right) \quad if \quad \gamma_i > \frac{1}{n} - \frac{1}{2}\left(1-\sum_i \gamma_i^2\right) \end{aligned}$$

All relations[14] follow directly from comparing the values for expected national welfare. From this corollary it follows that all but the biggest player prefer the fixed monetary policy to all three voting mechanisms. Moreover, $\gamma_n < \frac{1}{2}$ is sufficient (not necessary) for these players $i \neq n$ to prefer the optimal rule over any described voting rule. And the biggest player is better off than in the benchmark cases only under the vote distribution $\mathbf{w}^e$ which is the least preferred for all players.

For the proceeding it is helpful to note as well the following corollary regarding the pareto superiority of the joint optimal decision..

Corollary 4

$$E\left(W_{i,t}^{*}\right) \geq E\left(W_{i,t}\left(\phi_i\right)\right) \quad \forall i \quad \Leftrightarrow \phi_i \leq \gamma_i + \frac{1}{2}\left(1 - \sum_i \gamma_i^2\right) \quad \forall i$$

This corollary, which follows directly from (5) and (11), defines a condition for the voting game ensuring that every country is ex-ante pareto better off if the joint optimal decision could be implemented. The power (measured by the Shapley-Shubik index) should not exceed too much its importance. It is shown already in Corollary 3 that the voting weight vector $\mathbf{w}^p$ always fulfills this condition and that $\mathbf{w}^b$ fulfills it under an additional, not very restrictive, condition. But $\mathbf{w}^e$ violates this condition. Applying the voting weights yielding the most efficient outcome under the constraint of an impossibility of sidepayments prevents on the other hand that all countries have an incentive to implement the joint optimal monetary policy.

5 Full sidepayments

Now I consider the case that the members of the Council have the possibility for unlimited side payments. The discussion on how sidepayments could be introduced in the ECB will be done in section 6. The outcome

[14]The last condition always holds if $\gamma_n < \frac{1}{2}$ and $n \geq 4$ since then $\sum_i \gamma_i^2 < \frac{1}{2}$.

of the decision making process is a pair $(x_t, \mathbf{s}_t)$, where $\mathbf{s}_t = (s_{i,t})$ is the vector of sidepayments. Taking into account that allowing for sidepayments means opening a market (for monetary policy) that was missing in the previous section, it is straightforward that we get in this case the jointly optimal policy in every period.

Proposition 6 *In an EMU with sidepayments and satisfying* $(A1)$-$(A6)$ *we get* $x_t = x_t^* \quad \forall t.$[15]

Proof. Suppose a winning coalition $S \mid w_S > d$ forms and chooses $x_t = \hat{x}_t \neq x_t^*$ with

$$W_{i,t}(\hat{x}_t) > W_{i,t}(x_t^*) \quad \forall i \in S \quad \text{and} \quad W_{j,t}(\hat{x}_t) < W_{j,t}(x_t^*) \quad \forall j \in N \backslash S$$

Then the coalition $N \backslash S$ can form and offer every player $i \in S$ a sidepayment

$s_i = W_{i,t}(\hat{x}_t) - W_{i,t}(x_t^*)$ if S chooses x_t^* instead of $\hat{x}_t$.[16] Denote

$$W_S(x_t) = \sum_{i \in S} W_{i,t}(x_t), \quad W_{N \backslash S}(x_t) = \sum_{j \in N \backslash S} W_{j,t}(x_t), \quad s_S = \sum_{i \in S} s_i.$$

Because $\hat{x}_t \neq x_t^*$ we have

$$\begin{aligned} W_S(\hat{x}_t) + W_{N \backslash S}(\hat{x}_t) &< W_S(x_t^*) + W_{N \backslash S}(x_t^*) \\ \Leftrightarrow W_S(\hat{x}_t) - W_S(x_t^*) &< W_{N \backslash S}(x_t^*) - W_{N \backslash S}(\hat{x}_t) \\ s_S &< W_{N \backslash S}(x_t^*) - W_{N \backslash S}(\hat{x}_t) \end{aligned}$$

$N \backslash S$ can divide s_S such that

$$-s_j < W_{j,t}(x_t^*) - W_{j,t}(\hat{x}_t) \quad \forall j \in N \backslash S, \quad \sum_j -s_j = s_S \quad \left(\Rightarrow \sum_{k \in N} s_k = 0 \right).$$

[15]Note that $(A1)$ is only needed to ensure that the national optimal poicies $x_{i,t}^*$ do not depend on the sidepayments. Assumption $(A5)$ is crucial for this proposition.

[16]Throughout the paper side-payments are defined as positive when a player receives them and as negative when he has to pay.

Hence

$$(x_t^*, s_k) \succeq (\hat{x}_t, 0) \quad \forall k \in N. \qquad \blacksquare$$

We need a mechanism that determines how the jointly efficient outcome can be achieved, i.e. we have to specify the sidepayments. I assume that bargaining in the ECB follows the bargaining mechanism in Hart and Mas-Colell (1996). Since this model is based on a coalitional (or characteristic) function, we first have to construct such a function $\vartheta_t : 2^N \rightarrow \Re$.[17] In the tradition of von Neumann and Morgenstern $\vartheta_t(S)$ is usually the value that S can guarantee itself under the assumptions that the coalition of all other players ($N \backslash S$) forms and that it has strictly opposite interests to S [see Weber (1994)]. Both assumptions are questionable in our game. Since the monetary policy is a public good we should not assume that the game is constant-sum in his coalitional function. As a consequence it might not be the worst case for a coalition S if $N \backslash S$ forms but if only subsets $R \subset N \backslash S$ form. Evidently the coalitional function should be different for winning coalitions (WC), i.e. those coalitions S with $w_S \geq d$, and loosing coalitions (LC), i.e. those coalitions S with $w_S < d$. It is reasonable to assume that in any case a winning coalition (WC) will form. Following the original conservative perspective of the coalitional function I specify $\vartheta_t(S)$ as

$$\vartheta_t(S) = \begin{cases} \sum_{i \in S} W_{i,t}\left(x_{S,t}^*\right) & \text{if} \quad w_S \geq d \\ \min_{R \subset N \backslash S, w_R \geq d} \left\{ \sum_{i \in S} W_{i,t}\left(x_{R,t}^*\right) \right\} & \text{if} \quad w_S < d \end{cases} \text{[18]} \qquad (21)$$

where $x_{S,t}^*$ and $x_{R,t}^*$ are the solutions to the problems $\max_{x_t} \sum_{i \in S} -\gamma_i \left(x_{i,t}^* - x_t\right)^2$ resp. $\max_{x_t} \sum_{j \in R} -\gamma_j \left(x_{j,t}^* - x_t\right)^2$. Since a WC can implement the monetary policy which is jointly optimal for their members this is obviously the

[17] In order to avoid confusion with the coalitional function of the voting game I use ϑ instead of v for the bargaining game.

[18] This coalitional function does not fulfill the normalization $0 \in V(S)$, i.e. in our TU context $0 \leq v(S)$, which is used in Hart and Mas-Colell(1996). But since this requirement can be changed without loss of generality (see their Footnote 4), their results are valid for the coalitional function of this paper as well.

least they can get. Rationality implies that a WC would actually do so and hence a LC has to take this decisions as given, but it does not know which WC will form. Obviously ϑ_t is not constant-sum, but this is true for many applications of cooperative game theory [see e.g. Young (1994)]. Note that ϑ_t is a function of the random variables $x^*_{i,t}$ and the voting weights $\mathbf{w}$ since the latter determine whether a coalition is winning or loosing.

In order to apply the bargaining mechanism of Hart and Mas-Colell, the coalitional function has to fulfill the condition $\vartheta_t(S) + \sum_{j \in T \setminus S} \vartheta_t(j) \leq \vartheta_t(T) \quad \forall S \subseteq T$, which is the formulation for TU games of the monotonicity condition imposed by Hart and Mas-Colell for a coalitional function of a general NTU game. The following proposition shows that $\vartheta_t(S)$ fulfills even the stronger condition of superadditivity.

Proposition 7 (21) *is superadditiv, i.e.*

$$\vartheta_t(S) + \vartheta_t(T) \leq \vartheta_t(S \cup T) \quad \forall S \cap T = \emptyset, \quad S, T \subseteq N$$

Proof. see Appendix ■

Superadditivity means that there is always a incentive for players to form and to merge coalitions. Since monetary policy is a public good, superadditivity ensures that free-riding on the decisions of others is not the optimal strategy.

Since the individual preferences $x^*_{i,t}$ and the national welfare functions $W_{i,t}$ are time-independent, we can regard the decision making process in the ECB as a sequence of static bargaining games. I consider the non-cooperative bargaining game by Hart and Mas-Colell (1996) which is defined as follows:

Definition 1 *In each period there are (potentially infinite many) bargaining rounds. In each round one player $j \in R$ (R is the set of active players, in the first round we have $R = N$) is chosen randomly (with equal probability) and makes a (feasible) proposal. If all the other player agree, this proposal is the final outcome of the bargaining. If only one* *player refuses we move to the next round. In this round the set of active player is with probability ρ again R and with probability $1-\rho$ it is $R\backslash j$. If the proposer drops out he gets a final pay-off.*

The solution concept to this bargaining game is the concept of stationary subgame perfect equilibria (SPE), i.e. those subgame perfect equilibria where the equilibrium strategies does not depend on time. In our case this concept means that strategies depend on R and j but not on the number of the round.

In our game, a proposal is a pair $(x_t, \mathbf{s}_t)$ consisting of monetary policy and the vector of sidepayments. We can interprete the bargaining as one over the distribution of W_t and determine the sidepayments in a proposal indirectly by $s_{i,t} = b_{i,t} - W_{i,t}(x_t)$, where $b_{i,t}$ is the proposed share of $W_t(x_t)$ of player i. The final pay-off of a dropped-out proposer j in our game has to satisfy $s_{j,t} = 0$. Hence we get for the case $R = N$ that the final pay-off becomes $\vartheta(j)$ if proposer j has to drop out and the remaining player find an agreement.[19]

The defined bargaining game is an unanimity game since every player can prevent an agreement. The justification of using an unanimity rule when sidepayments are allowed in the EMU stems from the following arguments. The simple majority rule for deciding about x_t does not apply for proposals over sidepayments. There is, for obvious reasons, no mechanism described in the ECB statute that gives a majority in the voting game the possibility for extracting sidepayments from the minority against their will. In principle proposals of the kind $(\hat{x}_t, \hat{\mathbf{s}}_t)$ with $\hat{s}_{i,t} \geq 0 \quad \forall i \in S, \quad w_S < d$, cannot be rejected by a minority S. But it follows from proposition 11 that such a proposal will not be accepted by the majority itself since making concessions to the minority in exchange for sidepayments is beneficial for both sides. Hence the voting game influence the power of the player within the bargaining game, but the bargaining outcome finds and requires the acceptance of every player.

[19]Of course that final pay-off changes if $R \subset N$ or $R\backslash i$ find no agreement. In the article of Hart and Mas-Colell all these pay-offs are set to 0, but again this is just a question of normalization and should not change the results.

Proposition 1 of Hart and Mas-Colell (1996) says that the proposals of an SPE are always accepted, pareto optimal and that j proposes the other players their expected pay-off for the case anyone rejects the proposal. Theorem 2 of Hart and Mas-Colell (1996) states that the bargaining game has a unique SPE and that under $\rho \to 1$ the proposal in this SPE converges to the Shapley value $\boldsymbol{\psi}_t = (\psi_{i,t})$ of the game (N, ϑ_t),i.e.

$$\psi_{i,t} = \sum_{S \ni i} \frac{(s-1)!\,(n-s)!}{n!} \left[\vartheta_t(S) - \vartheta_t(S \backslash i)\right]. \tag{22}$$

Hence we have in equilibrium $b^*_{i,t} = \psi_{i,t}$ and thus

$$s^*_{i,t} = \psi_{i,t} - W_{i,t}(x^*_t). \tag{23}$$

It follows directly from these results that we can state the following theorem:

Theorem 1 *Suppose the ECB fulfills* (A1)-(A6), *allows for sidepayments and the bargaining within the ECB-Council follows in each period definition 1. Then in equilibrium each period one randomly chosen national governor makes the proposal* $(x^*_t, \mathbf{s}^*_t)$ *and every governor* i *votes for* x^*_t *and accepts* $\mathbf{s}^*_t$.

The distribution of voting weights does not affect the chosen monetary policy (since proposition 6 is true for any $\mathbf{w}$) but determines the distribution of pay-offs since $\mathbf{s}^*_t$ is via the coalitional function ϑ_t a function of $\mathbf{w}$. In order to compare different vote distribution from an ex-ante point of view, we have to compute the expected Shapley value for the different countries.

The expected value of the coalitional function (21) is given by

$$E(\vartheta_t(S)) = \begin{cases} -\sigma\left(\gamma_S - \frac{1}{\gamma_S}\sum_{j \in S}\gamma_j^2\right) & \text{if} \quad w_S \geq d \\ E\left(\min_{R \subset N \backslash S, w_R \geq d}\left\{\sum_{i \in S} W_{i,t}(x^*_{R,t})\right\}\right) & \text{if} \quad w_S < d \end{cases}, \tag{24}$$

where $\gamma_S = \sum_{i \in S} \gamma_i$. The computation of the expected value for a LC is quite complicated, especially since the $x^*_{R,t}$ are dependent random variables. But in principle this expected value can be determined when the complete distribution of the $x^*_{i,t}$ is given.

Under the assumption that the utility of a member is linear in the medium of the sidepayments we get for the expected utility (including $s^*_{i,t}$) of country i

$$E(\psi_{i,t}) = E\left(\sum_{S \ni i} \frac{(s-1)!\,(n-s)!}{n!}\left[\vartheta(S) - \vartheta(S \backslash i)\right]\right) \tag{25}$$

$$= \sum_{S \ni i} \frac{(s-1)!\,(n-s)!}{n!}\left[E(\vartheta(S)) - E(\vartheta(S \backslash i))\right] \tag{26}$$

The expected value of the sidepayments are given by $E(s_{i,t}) = E(\psi_{i,t}) - E(W_{i,t}(x^*_t))$, i.e. by the difference between (25) and (1).

6 Introduction of sidepayments in the ECB

We have seen that by introducing sidepayments the jointly efficient monetary policy can be implemented and that this would lead to a considerable welfare gain. The actual design of the ECB does not describe any sidepayments. It seems to be unrealistic that the countries supply their governors with an amount of money for making explicit sidepayments within the bargaining. One possibility would be to link the decisions of monetary policy implicitly to other policy issues outside the ECB. But since the ECB is independent it is difficult to find a way how a governor could make credible commitments for concessions on policy issues outside the ECB.

A more promising way to implement the efficient solution is to modify the statute of the ECB. It is reasonable to assume that the implementation is easier if the modification is only moderate. My proposal is to introduce sidepayments by changing the formula for calculating the shares of the ECB. Actually the share of a country (α_i) is defined as the mean of the share of population and the share of GDP. It is mentioned explicitly that the share should equal the relative importance of a country. Hence we can interpret the actual statute as one with $\alpha_i = \gamma_i$. Since population and GDP do not necessarily grow identical across countries, the shares have to be recalculated after a certain period even under the actual statute. According to this statute the shares determine the allocation of profits of the ECB. Hence the expected monetary value of the shares is the discounted stream of the expected future profits. I denote this value by EP and assume it to be positive.

Denote the number of periods between the recalculations of the shares with τ and denote the points in time for this recalculation with $T = 0, 1, ...$[20] Moreover denote the sum of sidepayments a country has to receive or to pay between $T - 1$ and T with

$$s_{i,T} = \sum_{t=(T-1)\cdot\tau+1}^{T\cdot\tau} s_{i,t}.$$

The proposal is to change the definition of the shares from

$$\alpha_{i,T+1} = \alpha_{i,T} + g_{i,T} \tag{27}$$

$$\text{to } \alpha_{i,T+1} = \alpha_{i,T} + g_{i,T} + \Delta_{i,T}(s_{i,T}), \tag{28}$$

where $g_{i,T}$ is the change in relative importance between T and $T+1$. For simplicity I assume that $E(g_{i,T}) = 0\ \forall i$. $\Delta_{i,T}(s_{i,T})$ is the new component that introduces sidepayments. In my view it is advantageous if $\Delta_{i,T}$ has a identical functional form for all i and for all T. For restricting the set of feasible functions I make the following proposition:

Proposition 8 $E(\Delta_{i,T}) = 0\ \forall i$ *is a necessary condition for implementing*

$x_t = x_t^* \quad \forall t$ *via the shares of the ECB.*

[20]E.g. we had monthly meetings of the ECB and the recalculation every second year, we had $\tau = 24$, t would be measured in month and T in two-years.

Proof.

$$\left(\sum_i E\left(\alpha_{i,T+1}\right)=\sum_i E\left(\alpha_{i,T}\right)=1\right)\Rightarrow\sum_i E\left(\Delta_{i,T}\right)=0$$

If $E\left(\Delta_{i,T}\right)=0\forall i$ does not hold, there exist some i with $E\left(\Delta_{i,T}\right)=E\left(\Delta_i\right)<0$. Taking a starting value $\alpha_{i,0}$ as given, we get for these countries

$$\exists T^o \mid E\left(\alpha_{i,T^o+1}\right)=\alpha_{i,0}+T^o\cdot E\left(\Delta_i\right)\leq 0$$

Since the shares have to be positive, this means that it will be expected in the beginning that these countries will loose all their shares at one point in time. Since shares are regarded here as the only possible medium of sidepayments, these countries cannot make sidepayments from T^o onwards. Thus their interests will not be taken into account and hence the optimal solution will not be implemented in all periods. ■

The following specification of $\Delta_{i,T}$ fulfills this condition:

$$\Delta_{i,T}=\frac{1}{EP}\left[s_{i,T}-E\left(s_{i,T}\right)\right],\quad \alpha_{i,0}=\gamma_{i,0} \tag{29}$$

Since EP is the expected value of the total shares, $\frac{s_{i,T}}{EP}$ gives the proportion of shares that equals the value of the sidepayments. The expected value of the shares of each country equals the original value, i.e.

$$\begin{aligned} E\left(\alpha_{i,T+1}\right) &= E\left(\alpha_{i,T}\right)+E\left(d_{i,T}\right)+\frac{1}{EP}\left[E\left(s_{i,T}\right)-E\left(E\left(s_{i,T}\right)\right)\right] \\ &= E\left(\alpha_{i,T}\right)=\alpha_{i,0} \end{aligned} \tag{30}$$

(29) implies that the sidepayments are effective not in T but in $T+1$. If $\Delta_{i,T}$ would depend on the actual central bank profit P_T (i.e. if the sidepayments would be executed without a lag), $E\left(\Delta_{i,T}\right)=0$ might not hold. Because the actual profits of the central bank depend surely on the chosen monetary policy, P_T and $s_{i,T}$ are both random variables depending on the national optimal policies between $T-1$ and T and hence not independent.

Subtracting $E\left(s_{i,T}\right)$ from $s_{i,T}$ is necessary for fulfilling the condition $E\left(\Delta_{i,T}\right)=0$. The preceding section has shown that the expected sidepayments are a function of the voting weights and the parameter of the model. Since this function is not continuous in $\mathbf{w}$, there exist almost surely some i with $E(s_{i,T}) < 0$. The formula works like endowing the countries with $E(s_{i,T}) < 0$ endogenously with the capability of making sidepayments of $E(s_{i,T})$. But if we take the existing statute as one with equal votes for each country, we have seen in section 4 that each country is better off with sidepayments in the ECB as long as no country is too powerful, i.e. as long the condition in corollary 4 holds. Hence changing the definition of the shares to (28) and (29) is pareto better in period 0. Thus implementing the new recalculation formula for the shares should be supported by every country. Moreover this formula avoids a complicated bargaining over the voting weights.

The definition in (29) is not sufficient to ensure the feasibility of introducing sidepayments by reformulating the existing adjustment formula of the shares. We have to regard as well the non-negativity constraints of the shares $\alpha_{i,T+1} \geq 0$. Even a restriction of the distribution of $x^*_{i,t}$ (leading to restrictions of $\Delta_{i,T}$) is not enough since a series of unfavorable realizations of the individual countries would lead to the occurrence of $\alpha_{i,T+1} < 0$ for some i.

A straightforward way of solving this problem is the following. A minimum value of the shares of all countries, $\alpha_{i,\min}(\geq 0)$, has to be defined. $\alpha_{i,\min} = 0 \quad \forall i$ is feasible but eventually one wants to limit the possibility that the shares of very small countries become larger than the ones of the big countries. If the calculation of shares according to (28) and (29) leads to $\alpha_{i,T+1} < \alpha_{i,\min}$ the national government of that country has to provide the governor with extra money. More specifically, if the value of shares arising from (29) is denoted with $\tilde{\alpha}_{i,T+1}$, the government has to pay $(\alpha_{i,\min} - \tilde{\alpha}_{i,T+1}) * EP$. This amount has to be distributed among the countries who raised their shares in T, e.g. proportionally to that raise. Thus we get in the case that there exist some i with $\tilde{\alpha}_{i,T+1} < \alpha_{i,\min}$ the following adjustment rule

$$\alpha_{i,T+1} = \begin{cases} \alpha_{i,\min} & \text{if } \tilde{\alpha}_{i,T+1} < \alpha_{i,\min} \\ \tilde{\alpha}_{i,T+1} & \text{if } \tilde{\alpha}_{i,T+1} \leq \alpha_{i,T} \\ \tilde{\alpha}_{i,T+1} - \frac{\tilde{\alpha}_{i,T+1}}{\sum\limits_{i:\tilde{\alpha}_{i,T+1} > \alpha_{i,T}} \left(\tilde{\alpha}_{i,T+1} - \alpha_{i,T}\right)} \cdot \sum\limits_{j:\tilde{\alpha}_{i,T+1} < \alpha_{i,\min}} \left(\alpha_{i,\min} - \tilde{\alpha}_{i,T+1}\right) & \\ \quad \text{if } \tilde{\alpha}_{i,T+1} > \alpha_{i,T} & \end{cases} \tag{31}$$

The adjustment implies that national governments have to intervene in the ECB system, but in a predefined way not allowing for political interventions. Still it would be wishful if the probability of these interventions is very low. This probability depends on the distribution of $x^*_{i,t}$, the value of EP, the chosen values of $\alpha_{i,\min}$ and the voting game v. From these two arguments only the latter two are choice variables. Obviously the probability of intervention decreases with lowering the values of $\alpha_{i,\min}$. A voting game v_1 can be regarded as better than another game v_2 if

$$prob\left(\left[s_{i,T} - E\left(s_{i,T}\right)\right] < \left(\alpha_{i,\min} - \tilde{\alpha}_{i,T+1}\right) EP\right) \tag{32}$$

is lower for all i.[21] The example in the following section illustrates how an appropriate allocation of voting weights helps to introduce sidepayments into the ECB without having a high probability that national governments must provide extra money to achieve the joint optimal monetary policy.

7 An Example

In this section I will use an example to illustrate the results in the previous sections. Since the decision about admission to the EMU will be made only in 1998 as a result of a bargaining process within the Council of the EU, based on the fulfilling of the convergence criteria, statements on the size of the starting EMU unavoidably have a speculative element.

[21] Another justification for $\alpha_{i,\min} > 0$ *for some* i can be founded on fairness considerations. Taking a voting game v as given, $\alpha_{\min} = (\alpha_{i,\min}, ..., \alpha_{i,\min})$ could be used to ensure that (32) is equal for all i.

Reflecting the current speculations, I assume that the EMU is formed by 11 countries, namely Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxemburg, the Netherlands, Portugal and Spain. If we focus on the inflation criterium, probably only Greece will fail it. Denmark, Sweden and the United Kingdom actually do not plan to join the EMU in the first stage.

Table 1 gives the importance measures of these countries, as defined in the statute, and the expected national and European welfare values in our benchmark cases from section 3, namely the joint optimal monetary policy x_t^* and the fixed monetary policy x^f.

The importance measures γ_i reflect that our EMU is formed by countries of very different size. The two biggest countries, Germany and France are together more important than the remaining 9 together. On the other hand, Luxemburgs importance is nearly negligible, it is less than 1%.

Column 3 of table 1 shows that the expected loss is continuous in the important measures of this EMU11.[22] But the difference between the expected loss of Germany and France is small given their difference in importance (Germany is nearly 50% more important than France but its expected loss is less than 10% higher). The reason is that size has two opposite effects on expected national welfare when the joint optimal policy is adopted. On one hand, since in bigger countries more people and a higher GDP is affected by monetary policy, the total loss from deciding an individually suboptimal policy increases with size. On the other hand, an increase in importance raises the influence on the joint optimal policy and hence reduces the loss. If a fixed monetary policy would be chosen, column 4 shows that while the expected total loss from this policy is nearly 25% higher than in the case of an optimal policy, only the big countries Germany, France, Italy and Spain would fare actually better under this regime.[23]

[22]This result does not necessarily hold for a smaller EMU, e.g. in a EMU consisting of Germany, France, Austria,Ireland and the Benelux countries the expected loss would for France would be the highest

[23]It should be noted that if we would introduce an additional common shock in the

Table 2 gives the expected national and European welfare when no sidepayments are allowed for the three voting weight allocation discussed in section 4. Due to the non-continuity of the Shapley-Shubik power index, the condition power equals importance (i.e. $\boldsymbol{\phi} = \boldsymbol{\gamma}$) cannot be fulfilled in our example for any voting game with a simple majority rule. The chosen vote allocation gives at least fairer results than the other.[24] In Brueckner (1996) this problem is discussed in more detail and it is shown as well that in a EMU consisting of all EU countries the condition $\boldsymbol{\phi} = \boldsymbol{\gamma}$ can almost be fulfilled. Note that for $\mathbf{w}^b$ and $\mathbf{w}^p$ the condition derived in corollary 10 holds so that in these cases implementing the joint optimal monetary policy is a pareto improvement.

Tables 3,4 and 5 consider the effects of implementing the joint optimal policy by allowing for sidepayments.

The tables give the expected Shapley values, expected sidepayments and the variance of the sidepayments for the alternative voting weight allocations $\mathbf{w}^b$, $\mathbf{w}^p$ and $\mathbf{w}^\gamma$. Instead of giving the sum of the sidepayments (which is always 0), the last row in columns 4 and 7 give the expected amount of money needed for sidepayments, i.e. they give

$$E(z_t) = E\left(\frac{1}{2}\sum_{i\in N}|s_{i,t}|\right).$$

Due to the described difficulties in deriving the theoretical expected Shapley values, the tables give the empirical values from a simulation. I specified the preferences $x_{i,t}^*$ as $U[-1,1]$ distributed, leading to $\sigma = \frac{1}{3}$.

preferences over monetray policy, this result would probably change. This is because the national welfare from a fixed monetary policy would decrease while from the optimal policy it remained unchanged.

[24]The corresponding vector of the Shapley-Shubik values is

$$\boldsymbol{\phi}^p = \frac{1}{100}[3.4; 3.95; 2; 45; 20.78; 32.45; 0.78; 17.05; 0.22; 6.1; 2.84; 9.99;]$$

. This can be regarded as fairer as $\mathbf{w} = \boldsymbol{\gamma}$ what would yield

$$\boldsymbol{\phi}^\gamma = \frac{1}{100}[1.91; 2.23; 21.91; 1.2; 38.82; 0.88; 19.69; 0.4; 3.66; 1.6; 7.71].$$

I chose 500 draws for each country from this distribution, with monthly meetings this would correspond to more of 40 years of our ECB. From these realizations of preferences over monetary policy I computed the coalitional functions v_t according to (21) and then the Shapley values and sidepayments as defined in (22) and (23).

Figures 1-3 show the development of shares over time according to formulas (28) and (29) with the adjustment in (31) for the cases when a country hits the lower border. For the border I took $\alpha_{i,\min} = 0 \quad \forall i$. More over I chose $\tau = 24$, with monthly meetings this corresponds to biannual recalculations of the shares. For the expected profits of the ECB I picked $EP = \frac{\tau}{6} = 4$. Note that the main purpose here is to illustrate that with an appropriate voting weight allocation it is less likely that countries actually hit the borders than with alternative vote allocations.

We see that with $\mathbf{w}^b$, i.e. equal votes for each country, Ireland and Luxemburg hit the lower border 1 resp. 2 out of 19 times. With $\mathbf{w}^\gamma$ Luxemburg hits the border three times, while no intervention of any government occurs by using $\mathbf{w}^p$.

One should be very careful with drawing conclusions from this one example. But it might indicate that, using the mechanisms developed in this paper, there is actual no trade-off but a complementarity between fairness (in terms of power) and efficiency (measures by potential negative impacts of, predefined, governmental interventions).[25] It seems that the volatility of the shares is higher when the power in the voting game differs substantially from the importance measure.[26] Under the rule one-country-one-vote Ireland and Luxemburg are extremely overrepresented. And $\mathbf{w}^\gamma$ yields in this example not only governmental interventions by Luxemburg but also a high volatility of the shares especially in the case of France. As a result France has once even the last but third lowest share of all countries, what could be explained with the high variance

[25]Similar findings occurred with a previous simulation for a EMU7.

[26]Note that in the absence of governmental interventions the variance of the shares is given by

$$Var_T\left(\alpha_{i,T+1}\right) = Var\left(d_{i,T}\right) + \tau \cdot Var\left(s_{i,t}\right)$$

of sidepayments for France. A possible explanation for this result is the difference between power and importance that is much higher in $\mathbf{w}^\gamma$ (and $\mathbf{w}^b$) than with $\mathbf{w}^p$. However, a more thorough estimation of the parameters of the model and a deeper investigation of the effects of different voting weight allocations is necessary to find the optimal voting weights.

8 Conclusion

In this paper a simple framework for an EMU with ex-ante identical preferences of the member states over monetary policy and random shocks was used to illustrate the influence of the distribution of voting weights on the monetary decisions and the distribution of welfare effects among the different countries. Due to the crucial role of the voting weights the votes assigned to every national central bank governor should not be given ad-hoc but after a thorough investigation of their welfare and distributional effects.

We have seen that without sidepayments the decisions will be suboptimal. Moreover in this situation there is a strong trade-off between efficiency and fairness. The expected welfare is maximized if the most important country has a majority of votes for its own. This solution seems hardly be acceptable for the other countries. Furthermore it removes the incentive for the most important country to implement the joint efficient solution.

There is a substantial welfare gain by allowing for sidepayments. The Application of the bargaining game introduced by Hart and Mas-Colell (1996) has shown how the efficient solution can be implemented in a non-cooperative manner. In this case the allocation of voting weights determines uniquely the expected distribution of benefits. These results can be used not only for the ECB but also for the analysis of many other institutions where sidepayments can be introduced and where voting procedures are used to find a final decision.

The substantial improvement of the system with sidepayments indicates that it is worthwhile to look for concrete procedures how sidepayments can be introduced. The analysis is section 6 has shown that with redefining the shares a moderate change in the statute of the ECB is sufficient for a pareto improvement of the European Monetary Union. Moreover the simulation in section 7 has indicated that there might be a complementarity between fairness and efficiency.

An interesting extension of the model would be to analyze the case where not all of the members have ex-ante identical preferences towards monetary policy and where the random shocks may be partly correlated. Since the analysis in sections 5 and 6 did not depend on identical distributed preferences, their main results would remain unchanged. But it might occur that some countries (those with a high probability of being the median voter in the game without sidepayments) are no longer better off if the joint optimal monetary policy is implemented. Hence additional effort might be necessary to overcome their resistance against an introduction of sidepayments. If implementing the jointly efficient monetary policy is not feasible, intermediate scenarios are possible. In the case that a minority has systematically diverging preferences, the majority might be able to implement their (group-)optimal policy without having to take the interests of the minority into account.

A Proofs

Proof of Proposition 3:

Denote the set of players with preferences 'left' resp. 'right' of player i with

$$L_i = \left\{j \mid x^*_{j,t} \leq x^*_{i,t}, \quad j \neq i\right\}, \quad R_i = \left\{j \mid x^*_{j,t} \geq x^*_{i,t}, \quad j \neq i\right\}$$

The median m is the player i who fulfills the condition

$$(w_{L_i} < d) \wedge (w_{R_i} < d) \tag{33}$$

It follows directly from $(A2)$ that a unique median exists. Then we have

$$\begin{aligned} \forall i \in \{L_m \cup m\} : x^*_{m,t} &\succeq \hat{x}_t \quad if \quad x^*_{m,t} < \hat{x}_t \\ (w_{L_m} + w_m > d) &\Rightarrow \left(x_t \leq x^*_{m,t}\right) \quad (34) \\ \forall i \in \{R_m \cup m\} : x^*_{m,t} &\succeq \hat{x}_t \quad if \quad x^*_{m,t} > \hat{x}_t \\ (w_{R_m} + w_m > d) &\Rightarrow \left(x_t \geq x^*_{m,t}\right) \quad (35) \\ ([34] \wedge [35]) &\Rightarrow x_t = x^*_{m,t} \quad \blacksquare \end{aligned}$$

Proof of Proposition 11

The proof will be done for the three possible cases $(w_S \geq d)$,

$(w_S < d \wedge w_{S \cup T} < d)$ and $(w_S < d \wedge w_{S \cup T} \geq d)$. Here we assumed without loss of generality that $w_S \geq w_T$

1. $(w_S \geq d)$:

$$\begin{aligned} \vartheta_t(S) &= \sum_{i \in S} W_{i,t}\left(x^*_{S,t}\right), \qquad \vartheta_t(T) = \min_{R \subset N \setminus T, w_R \geq d} \left\{\sum_{i \in T} W_{i,t}\left(x^*_{R,t}\right)\right\} \\ \vartheta_t(T) &\leq \sum_{i \in T} W_{i,t}\left(x^*_{S,t}\right) \text{ since } S \subset N \setminus T \text{ and } w_S \geq d \\ \vartheta_t(S) + \vartheta_t(T) &\leq \sum_{i \in S \cup T} W_{i,t}\left(x^*_{S,t}\right) \leq \sum_{i \in S \cup T} W_{i,t}\left(x^*_{S \cup T,t}\right) = \vartheta_t(S \cup T) \end{aligned}$$

2. $(w_S < d \wedge w_{S\cup T} < d)$: Denote

$$\begin{aligned}
\mathcal{RS} &= \{R \mid R \subset N\backslash S, w_R \geq d\}, \quad \mathcal{RT} = \{R \mid R \subset N\backslash T, w_R \geq d\} \\
\mathcal{RST} &= \{R \mid R \subset N\backslash (S \cup T), w_R \geq d\} \\
RST &= R \mid \vartheta_t (S \cup T) = \sum_{i\in S\cup T} W_{i,t}\left(x^*_{R,t}\right)
\end{aligned}$$

Then we get

$$\begin{aligned}
\vartheta_t (S) &\leq \sum_{i\in S} W_{i,t}\left(x^*_{RST,t}\right) \text{ since } \mathcal{RS} \supseteq \mathcal{RST} \\
\vartheta_t (T) &\leq \sum_{i\in T} W_{i,t}\left(x^*_{RST,t}\right) \text{ since } \mathcal{RT} \supseteq \mathcal{RST} \\
\vartheta_t (S) + \vartheta_t (T) &\leq \sum_{i\in S\cup T} W_{i,t}\left(x^*_{RST,t}\right) = \vartheta_t (S \cup T)
\end{aligned}$$

3.$(w_S < d \wedge w_{S\cup T} \geq d)$: First note that

$$\begin{aligned}
x^*_{S\cup T,t} &= \frac{1}{\gamma_S + \gamma_T} \sum_{i\in S\cup T} \gamma_i x^*_{i,t} = \frac{\gamma_S \cdot x^*_{S,t} + \gamma_T \cdot x^*_{T,t}}{\gamma_S + \gamma_T} \\
\gamma_S &= \sum_{i\in S} \gamma_i \quad , \gamma_T = \sum_{i\in T} \gamma_i
\end{aligned}$$

Denote the players outside $S \cup T$ with $K = N\backslash (S \cup T)$. We have

$$\vartheta_t (S) \leq -\sum_{i\in S} \gamma_i \left(x^*_{i,t} - x^*_{T\cup K,t}\right)^2, \vartheta_t (T) \leq -\sum_{j\in T} \gamma_j \left(x^*_{j,t} - x^*_{S\cup K,t}\right)^2$$

Hence it is sufficient to proof that

$$\begin{aligned}
\sum_{i\in S} \gamma_i \left(x^*_{i,t} - x^*_{T\cup K,t}\right)^2 + & \sum_{j\in T} \gamma_j \left(x^*_{j,t} - x^*_{S\cup K,t}\right)^2 - \sum_{i\in S} \gamma_i \left(x^*_{i,t} - x^*_{S\cup T,t}\right)^2 \\
- & \sum_{j\in T} \gamma_j \left(x^*_{j,t} - x^*_{S\cup T,t}\right)^2 \geq 0
\end{aligned}$$

or

$$\begin{aligned}
& F\left(x^*_{1,t}, ...x^*_{n,t}\right) = \gamma_S \left(\frac{\gamma_T x^*_{T,t} + \gamma_K x^*_{K,t}}{1 - \gamma_S}\right)^2 - 2\gamma_S x^*_{S,t} \frac{\gamma_T x^*_{T,t} + \gamma_K x^*_{K,t}}{1 - \gamma_S} \\
& + \gamma_T \left(\frac{\gamma_S x^*_{S,t} + \gamma_K x^*_{K,t}}{1 - \gamma_T}\right)^2 - 2\gamma_T x^*_{T,t} \frac{\gamma_S x^*_{S,t} + \gamma_K x^*_{K,t}}{1 - \gamma_T} \\
- \quad & (\gamma_S + \gamma_T) \left(\frac{\gamma_S x^*_{S,t} + \gamma_T x^*_{T,t}}{\gamma_S + \gamma_T}\right)^2 + 2\left(\gamma_S x^*_{S,t} + \gamma_T x^*_{T,t}\right) \frac{\gamma_S x^*_{S,t} + \gamma_T x^*_{T,t}}{\gamma_S + \gamma_T} \geq 0
\end{aligned}$$

Note that $F\left(x_{1,t}^*, ...x_{n,t}^*\right) = F\left(x_{1,t}^* + c, ...x_{n,t}^* + c\right)$ for every constant c. Hence we can use without loss of generality the normalization $x_{S,t}^* = \frac{1}{\gamma_S}\sum_{i\in S}\gamma_i x_{i,t}^* = 0$. Thus it is sufficient to analyse

$$\begin{aligned} f\left(x_{T,t}^*, x_{K,t}^*\right) &= \gamma_S\left(\frac{\gamma_T x_{T,t}^* + \gamma_K x_{K,t}^*}{1-\gamma_S}\right)^2 + \gamma_T\left(\frac{\gamma_K x_{K,t}^*}{1-\gamma_T}\right)^2 - 2\gamma_T x_{T,t}^* \frac{\gamma_K x_{K,t}^*}{1-\gamma_T} \\ &\quad - (\gamma_S+\gamma_T)\left(\frac{\gamma_T x_{T,t}^*}{\gamma_S+\gamma_T}\right)^2 + 2\gamma_T x_{T,t}^* \frac{\gamma_T x_{T,t}^*}{\gamma_S+\gamma_T} \end{aligned}$$

We see immediately that $f(0,0) = 0$ and $Df(0,0) = 0$. Hence it is sufficient to proof that $f\left(x_{T,t}^*, x_{K,t}^*\right)$ is convex. The second deritives $D^2 f$ can be written as

$$2\cdot\begin{bmatrix} \gamma_T^2\left(\frac{\gamma_S}{(1-\gamma_S)^2}+\frac{1}{\gamma_S+\gamma_T}\right) & ;\gamma_T(1-\gamma_S-\gamma_T)\left(\frac{\gamma_S}{(1-\gamma_S)^2}-\frac{1}{1-\gamma_T}\right) \\ \gamma_T(1-\gamma_S-\gamma_T)\left(\frac{\gamma_S}{(1-\gamma_S)^2}-\frac{1}{1-\gamma_T}\right) & ;(1-\gamma_S-\gamma_T)^2\left(\frac{\gamma_S}{(1-\gamma_S)^2}+\frac{\gamma_T}{(1-\gamma_T)^2}\right) \end{bmatrix}$$

This matrix is positiv definit (and thus $f\left(x_{T,t}^*, x_{K,t}^*\right)$ convex) since

$$\gamma_T^2\left(\frac{\gamma_S}{(1-\gamma_S)^2}+\frac{1}{\gamma_S+\gamma_T}\right) > 0 \text{ and}$$

$$\gamma_S^2(4-\gamma_S-\gamma_T) > 0^{27}$$

■

[27] The last expression arises from computing the sign of $det\left(D^2 f\right)$.

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C Tables and Figures

Table 1: Importance and expected welfare in the benchmark cases

Country	γ_i	$E\left(W_{i,t}^{*}\right)$	$E\left(W_i^f\right)$
Austria	0.0305	-0.0346·σ	-0.0305·σ
Belgium	0.0367	-0.0412·σ	-0.0367·σ
Finland	0.0178	-0.0206·σ	-0.0178·σ
France	0.2128	-0.1640·σ	-0.2128·σ
Germany	0.3124	-0.1785·σ	-0.3124·σ
Ireland	0.0112	-0.0131·σ	-0.0112·σ
Italy	0.1863	-0.1534·σ	-0.1863·σ
Luxemburg	0.0020	-0.0023·σ	-0.0020·σ
Netherlands	0.0553	-0.0600·σ	-0.0553·σ
Portugal	0.0248	-0.0284·σ	-0.0248·σ
Spain	0.1103	-0.1076·σ	-0.1103·σ
EMU(total)	1	-0.8039·σ	-σ

Source: Own calculations, the data for computing γ is taken from OECD (1997)

Table 2: Expected welfare without sidepayments

Country	$\mathbf{w}^e$	$E\left(W_{i,t}^e\right)$	$\mathbf{w}^b$	$E\left(W_i^b\right)$	$\mathbf{w}^p$	$E\left(W_i^p\right)$
Austria	1	-0.0610·σ	1	-0.0553·σ	31	-0.0589·σ
Belgium	1	-0.0735·σ	1	-0.0668·σ	38	-0.0706·σ
Finland	1	-0.0356·σ	1	-0.0323·σ	18	-0.0347·σ
France	1	-0.4256·σ	1	-0.3869·σ	213	-0.3371·σ
Germany	11	0	1	-0.5679·σ	277	-0.4220·σ
Ireland	1	-0.0224·σ	1	-0.0204·σ	11	-0.0222·σ
Italy	1	-0.3726·σ	1	-0.3387·σ	187	-0.3091·σ
Luxemburg	1	-0.0039·σ	1	-0.0036·σ	1	-0.0039·σ
Netherlands	1	-0.1105·σ	1	-0.1005·σ	59	-0.1038·σ
Portugal	1	-0.0495·σ	1	-0.0450·σ	25	-0.0481·σ
Spain	1	-0.2206·σ	1	-0.2006·σ	145	-0.1986·σ
EMU(total)	21	-1.3753·σ	11	-1.8182·σ	1005	-1.6091·σ

Source: Own calculations

Table 3: Cases with sidepayments

Country	$\mathbf{E}\left(\psi_{i,t}^b\right)$	$E\left(s_{i,t}^b\right)$	$Var\left(s_{i,t}^b\right)$
Austria	0.0208·σ	0.0561·σ	0.3183·$\sigma \cdot 10^{-3}$
Belgium	0.0088·σ	0.0496·σ	0.3117·$\sigma \cdot 10^{-3}$
Finland	0.0464·σ	0.0674·σ	0.3729·$\sigma \cdot 10^{-3}$
France	-0.2743·σ	-0.1060·σ	2.1241·$\sigma \cdot 10^{-3}$
Germany	-0.4059·σ	-0.2298·σ	7.3395·$\sigma \cdot 10^{-3}$
Ireland	0.0602·σ	0.0729·σ	0.4259·$\sigma \cdot 10^{-3}$
Italy	-0.2260·σ	-0.0766·σ	1.3386·$\sigma \cdot 10^{-3}$
Luxemburg	0.0783·σ	0.0805·σ	0.4990·$\sigma \cdot 10^{-3}$
Netherlands	-0.0269·σ	0.0334·σ	0.2911·$\sigma \cdot 10^{-3}$
Portugal	0.0328·σ	0.0603·σ	0.3447·$\sigma \cdot 10^{-3}$
Spain	-0.1164·σ	-0.0079·σ	0.5867·$\sigma \cdot 10^{-3}$
EMU(total)	-0.8022·σ	0.4326·σ	13.953·$\sigma \cdot 10^{-3}$

Source: Own calculations

Table 4: Cases with sidepayments (cont.)

Country	$\mathbf{E}\left(\psi_{i,t}^{\gamma}\right)$	$E\left(s_{i,t}^{\gamma}\right)$	$Var\left(s_{i,t}^{\gamma}\right)$
Austria	-0.0358$\cdot\sigma$	-0.0004$\cdot\sigma$	$0.0543\cdot\sigma\cdot10^{-3}$
Belgium	-0.0418$\cdot\sigma$	-0.0010$\cdot\sigma$	$0.0755\cdot\sigma\cdot10^{-3}$
Finland	-0.0194$\cdot\sigma$	0.0016$\cdot\sigma$	$0.0177\cdot\sigma\cdot10^{-3}$
France	-0.1811$\cdot\sigma$	-0.0129$\cdot\sigma$	$4.5946\cdot\sigma\cdot10^{-3}$
Germany	-0.1569$\cdot\sigma$	0.0192$\cdot\sigma$	$2.7676\cdot\sigma\cdot10^{-3}$
Ireland	-0.0102$\cdot\sigma$	0.0025$\cdot\sigma$	$0.0104\cdot\sigma\cdot10^{-3}$
Italy	-0.1451$\cdot\sigma$	0.0044$\cdot\sigma$	$3.9622\cdot\sigma\cdot10^{-3}$
Luxemburg	-0.0006$\cdot\sigma$	0.0028$\cdot\sigma$	$0.0100\cdot\sigma\cdot10^{-3}$
Netherlands	-0.0628$\cdot\sigma$	-0.0025$\cdot\sigma$	$0.2168\cdot\sigma\cdot10^{-3}$
Portugal	-0.0262$\cdot\sigma$	0.0012$\cdot\sigma$	$0.0331\cdot\sigma\cdot10^{-3}$
Spain	-0.1235$\cdot\sigma$	-0.0149$\cdot\sigma$	$1.0200\cdot\sigma\cdot10^{-3}$
EMU(total)	-0.8022$\cdot\sigma$	0.1653$\cdot\sigma$	$12.762\cdot\sigma\cdot10^{-3}$

Source: Own calculations

Table 5: Cases with sidepayments (cont.)

Country	$\mathbf{E}\left(\psi_{i,t}^{p}\right)$	$E\left(s_{i,t}^{p}\right)$	$Var\left(s_{i,t}^{p}\right)$
Austria	-0.0256$\cdot\sigma$	0.0098$\cdot\sigma$	$0.0463\cdot\sigma\cdot10^{-3}$
Belgium	-0.0301$\cdot\sigma$	0.0107$\cdot\sigma$	$0.0668\cdot\sigma\cdot10^{-3}$
Finland	-0.0106$\cdot\sigma$	0.0104$\cdot\sigma$	$0.0329\cdot\sigma\cdot10^{-3}$
France	-0.1871$\cdot\sigma$	-0.0189$\cdot\sigma$	$2.5892\cdot\sigma\cdot10^{-3}$
Germany	-0.2014$\cdot\sigma$	-0.0254$\cdot\sigma$	$2.3366\cdot\sigma\cdot10^{-3}$
Ireland	-0.0109$\cdot\sigma$	0.0018$\cdot\sigma$	$0.0069\cdot\sigma\cdot10^{-3}$
Italy	-0.1632$\cdot\sigma$	-0.0137$\cdot\sigma$	$2.2597\cdot\sigma\cdot10^{-3}$
Luxemburg	-0.0011$\cdot\sigma$	-0.0011$\cdot\sigma$	$0.0014\cdot\sigma\cdot10^{-3}$
Netherlands	-0.0463$\cdot\sigma$	0.0140$\cdot\sigma$	$0.2013\cdot\sigma\cdot10^{-3}$
Portugal	-0.0179$\cdot\sigma$	0.0095$\cdot\sigma$	$0.0326\cdot\sigma\cdot10^{-3}$
Spain	-0.1079$\cdot\sigma$	0.0006$\cdot\sigma$	$0.7617\cdot\sigma\cdot10^{-3}$
EMU(total)	-0.8022$\cdot\sigma$	0.1451$\cdot\sigma$	$8.3354\cdot\sigma\cdot10^{-3}$

Source: Own calculations.

Figure 1: Developement of shares; $w_i = 1 \quad \forall i$

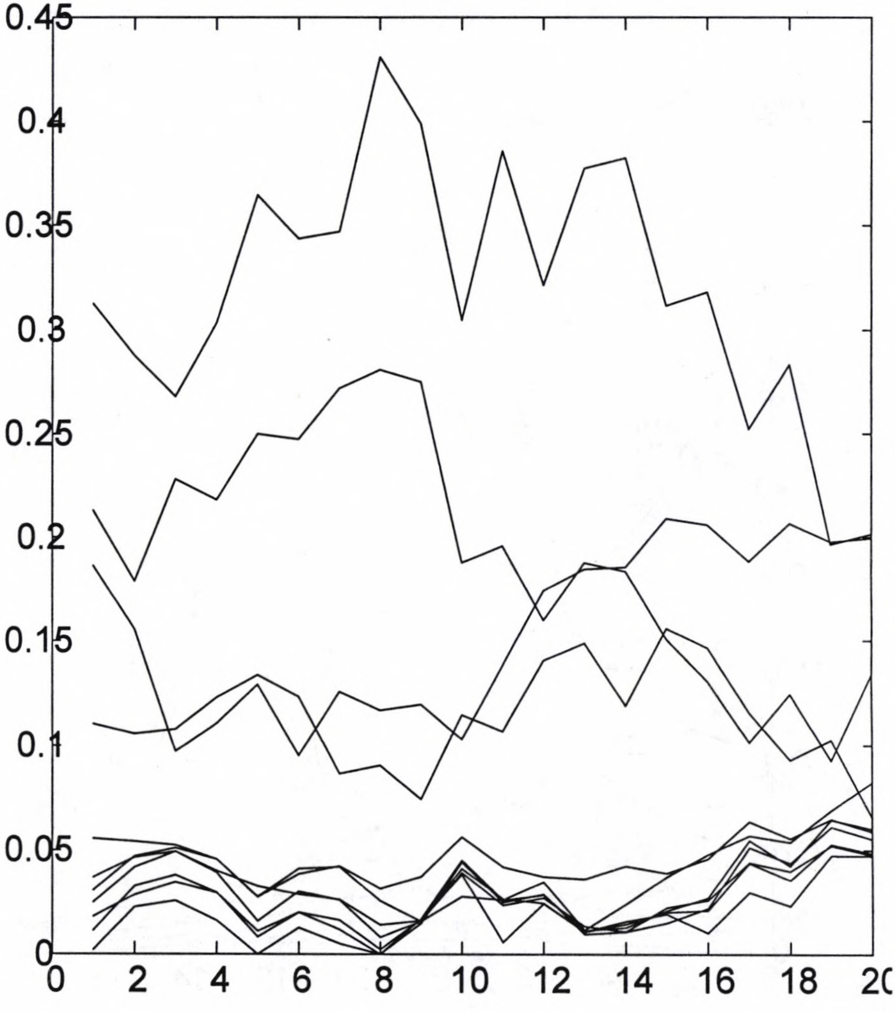


Figure 2: Developement of shares, $\mathbf{w} = \boldsymbol{\gamma}$

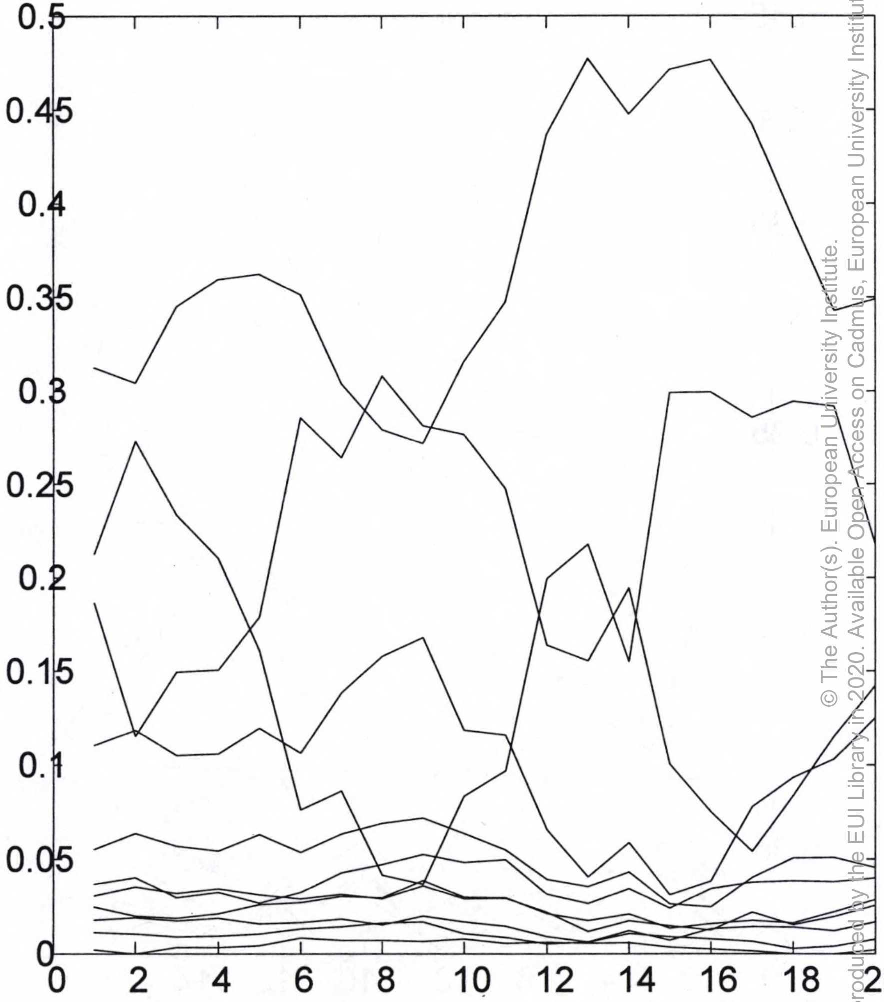
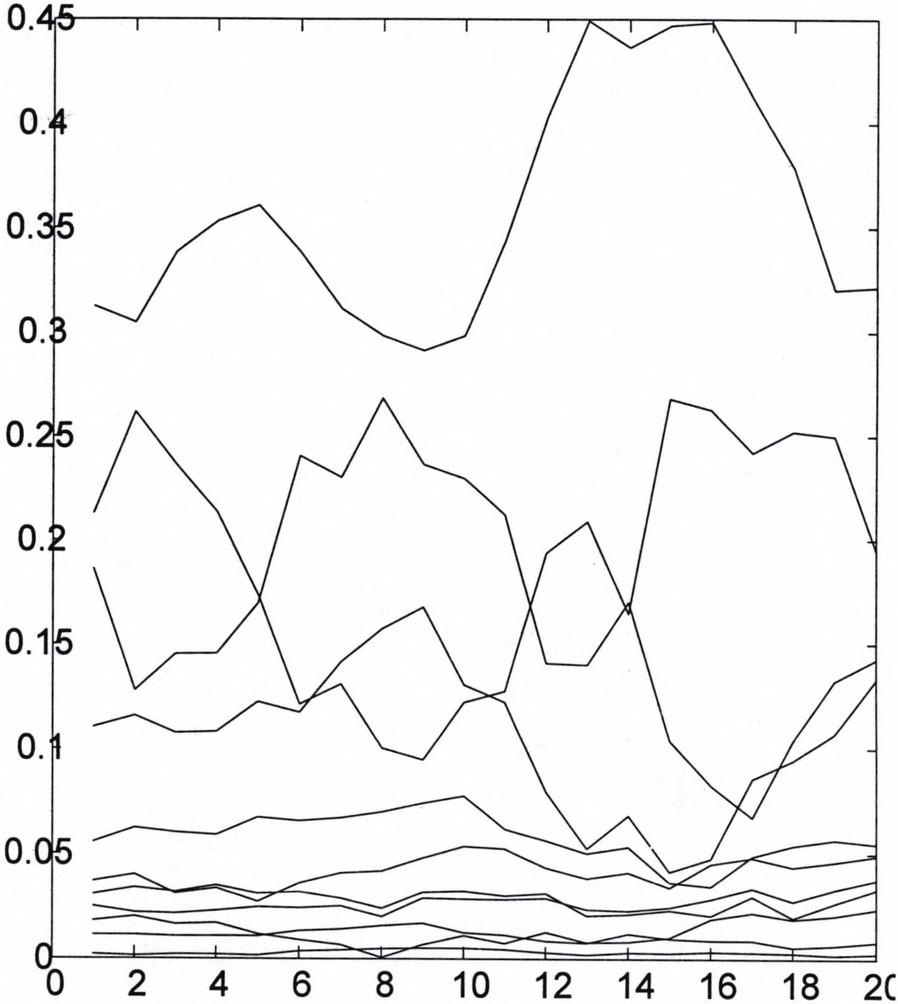


Figure 3: Developement of shares, $\mathbf{w} = \mathbf{w}^p$



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