How committees reduce the volatility of policy rates

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Abstract

This paper relates the volatility of interest rates to the collective nature of monetary policymaking in monetary unions. Several decision rules are modelled, including hegemonic and democratic procedures, and also committees headed by a chairman. A ranking of decision rules in terms of the volatility of policy rates is obtained, showing that the presence of a chairman has a cooling effect. However, members of a monetary union are better off under symmetric rules (voting, consensus, bargaining), unless they themselves chair the union. The results are robust to the inclusion of heterogeneities among members of the monetary union.

Keywords : Monetary Policy Committees, Decision Procedures, Interest-rate, Monetary Union

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1 Introduction

"An absolute yawning gap" (Goodhart, 1999): This is how the difference between monetary policy as it is implemented by central banks, and what it should be according to economic theory, can be described. In other words, while most academic models of interest rate setting imply that policy responses to shocks should be swift, central banks seem extremely prudent when they set their policy rates. This gap is mirrored in the general public's and practitioners' concern that central banks react "too little, too late", as the BIS (1998) noted.

True, several rationalizations of that puzzle have been put forward to explain why the observed inertia of central banks may indeed be optimal. It has thus been argued that the volatility of policy rates may harm central banks' credibility (Goodhart, 1999), or financial markets (Rudebusch, 1995, or Goodfriend, 1991), or that persistent policy rates may be an optimal answer to uncertainty (Aoki, 2001), or to the persistence of the economy itself (Rudebusch, 2002). Woodford (1999) also argued that in the presence of forward-looking expectations, managing policy rates in a predictable and smooth way is necessary to influence medium term interest rates, and make monetary policy effective. However, central banks' actual behaviour need not be optimal, and, as any bureaucracy's, it may simply result from their institutional environment. A convincing account of central banks' observed actions therefore needs to pay greater attention to the institutional constraints that central bankers face.

A key characteristic of today's central banking may precisely prove essential here, namely that monetary policy is a collective decision. To be specific, there are only three countries left, namely New Zealand, Norway, and Malta, and possibly Canada as Blinder (2004) points out, where monetary policy is still in the hands of a single governor. Elsewhere, committees are the rule. This feature of modern central banks implies that a decision has to be taken among committee members, which is likely to dampen the fluctuations of policy rates, especially if monetary policy committees are heterogeneous, as von Hagen (1999), Heinemann and Huefner (2004), or Meade and Sheets (2005) suggest.

Nonetheless, only a handful of contributions have so far studied the consequences of committees on monetary policy, let alone on the volatility of policy rates. This is the case of Cothren (1988), Sibert (2003), and Fatum (2006), who focus on the impact of monetary policy committees on their institution's reputation building and on the level of inflation. Gerlach-Kristen (2006) also underlines that committees are an efficient way to deal with monetary uncertainty about the economy, while Waller (2002) stresses that monetary policy committees are a way to cope with political uncertainty. Hefeker (2003), Matsen and Røisland (2005) and

Gros and Hefeker (2007) study the welfare consequences of decision rules in a monetary union. But, the only reference that explicitly relates the low degree of reactivity of central banks to the existence of monetary policy committees is, to our knowledge, Gerlach-Kristen (2005). However, she only studies a limited set of decision rules, and does not investigate their impact on welfare. Moreover, in her model, policymakers only differ in the information they hold about the state of the economy, which overlooks regional heterogeneities among committee members.

The aim of the present paper is precisely to relate monetary policy's lack of responsiveness to decision-making in monetary policy committees whose members represent different regions or sectors. In doing so, we extend the literature in several respects. First, we show how asymmetric regional shocks can affect the policy rates set by a federal monetary policy committee. Second, we study both a symmetric monetary union and an asymmetric monetary union, and compare monetary policy in both. Third, we most of all study a large spectrum of decision rules, some of which have not been studied so far in the literature on monetary policy. We in particular model the behaviour of a monetary policy committee headed by a chairman, a realistic feature of monetary policy committees that has nevertheless been neglected so far. Finally, we consider the welfare implications of all the decision rules studied. We thus obtain a ranking of decision rules in terms of volatility of the chosen policy rate, and in terms of welfare. We show in particular that having a chairman reduces the volatility of policy rates. We finally find that asymmetries matter for the ranking of decision rules not only in terms of welfare but also in terms of the volatility of the interest rate.

To do so, the rest of this paper is organised as follows. Section 2 sets up the model on which our reasoning rests. The following section investigates the consequences of delegating monetary policy to a hegemonic decision-maker. Section 4 studies the consequences of democratic decision rules. Section 5 introduces a chairman in the working of the monetary policy committee, and studies the consequences of all the decision rules studied in the presence of asymmetries between member countries. Section 6 concludes.

2 A simple model

The model basically consists of a description of the economic structure of a monetary union[1] and a specification of policy-making bodies' pref-

[1] Be this monetary union a collection of productive sectors, regions, or countries. For conciseness' sake, all our interpretations will be delivered in terms of countries in the rest of the paper, though our results can be read in a regional or sectorial perspective.

erences. In this section, we first describe these two building blocks and then compute each policy-maker's optimal interest rate as a function of each country's characteristics.

2.1 The economy

We assume that the union consists of n economies, indexed by j. The aggregate demand of an economy j is then described by the following equation:

$$y_{j,t}^{d} = -\alpha\left(i_t - \pi_{j,t}\right) + \gamma_{j,t} + \varepsilon_t \tag{1}$$

where $y_{j,t}^{d}, i_t, \pi_{j,t}$ are the aggregate demand, the interest rate and the inflation rate of this economy at time t. In addition, γ and ε respectively designate period t's local and federal demand shocks, whereas α is a positive parameter.

On the other hand, each economy's aggregate supply is given by a Lucas-type supply function where unexpected inflation boosts output:

$$y_{j,t}^{s} = \beta\left(\pi_{j,t} - \pi_t^{e}\right) + \eta_{j,t} + \upsilon_t \tag{2}$$

$y_{j,t}^{s}$ and π_t^{e} respectively designate aggregate supply and the expected inflation rate, while η and υ represent period t's local and federal supply shocks, respectively. Also, β is a positive parameter.

Hence, in the equilibrium, we obtain :

$$\pi_{j,t} = \frac{1}{\beta-\alpha}\left(-\alpha i_t + \beta\pi_t^{e} + \gamma_{j,t} - \eta_{j,t} + \varepsilon_t - \upsilon_t\right) \tag{3}$$

$$y_{j,t} = \frac{\beta}{\beta-\alpha}\left(-\alpha i_t + \alpha\pi_t^{e} + \gamma_{j,t} - \frac{\alpha}{\beta}\eta_{j,t} + \varepsilon_t - \frac{\alpha}{\beta}\upsilon_t\right) \tag{4}$$

We suppose $\alpha < \beta$, to rule out unrealistic behaviour of inflation relatively to its determinants.

The n local economies we consider differ from each other only due to the contemporaneous asymmetric shocks with which they are confronted. The shocks are all normally distributed with well-defined variances and zero means, and orthogonal to each other. We consider the federal economy to be sufficiently large for asymmetric shocks to offset each other at every period, so that:

$$\sum_{j=1}^{n}\gamma_{j,t} = 0 \text{ and } \sum_{j=1}^{n}\eta_{j,t} = 0 \tag{5}$$

Another possible interpretation of this is that each country's supply and demand shocks can be decomposed into a federal component and a national component. The common component can be obtained by taking the mean of national shocks, and the national components are the difference between the local shocks and their mean value, which are zero by the construction of our model. This notation also implies that national economies are of the same size.[2]

Since we consider that the federal economy has the same structure as local ones, the aggregation process delivers the following results for the federal economy :

$$\pi_t^f = \frac{1}{\beta - \alpha} \left(-\alpha i_t + \beta \pi_t^e + \varepsilon - \upsilon_t\right) \tag{6}$$

$$y_t^f = \frac{\beta}{\beta - \alpha} \left(-\alpha i_t + \alpha \pi_t^e + \varepsilon_t - \frac{\alpha}{\beta} \upsilon_t\right) \tag{7}$$

where π_t^f and y_t^f are the federal inflation and output. These expressions show that the only shocks remaining at the federal level are the common shocks.

2.2 The monetary policymakers

The key feature of our model is that monetary policy is decided by a federal college, consisting of country representatives (the governors). We also suppose that those representatives partly agree on the objectives to be followed. Namely, they all target the same inflation rate and the same output, which is consistent with Carraro's (1989) estimate of central bankers' preferences, finding no significant differences among central bankers' policy targets.[3] Accordingly, each representative (governor) has the following loss function :

$$G_{j,t} = \frac{1}{2} \left(\pi_{j,t} - \pi^*\right)^2 + \frac{\lambda}{2} \left(y_{j,t} - y^*\right)^2 \tag{8}$$

We assume that the desired inflation and output rates (π^* and y^*) are identical across governors. Hence, even though we do not impose a

[2] One may also interpret domestic disturbances as the country-specific impact of common disturbances.

[3] We consider that all governors possess the same information about the state of the economies. This assumption is consistent with Macklem's (2002) observation that in prominent monetary policy committees (e.g. those of the European Central Bank, the Federal Reserve Board, the Bank of Canada or the Bank of England), meetings start with the presentation by each member of his/her view of the economic situation. When committee members start bargaining, they therefore have the same information. For the treatment of monetary policy committee members basing their decisions on different information, one may however refer to Sibert (2003) or Gerlach-Kristen (2004, 2005).

common pre-specified federal objective, we consider policy-makers with similar preferences structure.[4] As in Drazen (2000), we define y^* as the difference between the desired and the natural output growth rate. In our context, this simply means that each economy may have a different natural output growth rate, though all governors (members of the board) wish to minimize the gap between their actual and optimal growth rates. For the sake of simplicity, we assume the same preferences for the monetary delegates (identical λ). The assumption of common inflation objectives across the union does not seem unrealistic, for instance in the European context, where inflation rates convergence is a pre-condition to monetary unification. We can thus normalize: $\pi^* = y^* = 0$.[5]

To complete the description of monetary policy, we must finally specify the timing of policy decisions. Namely, we assume that private agents form their expectations first, and that the values of shocks are subsequently revealed. The monetary authority can then set its policy rate. Finally, transactions occur, which determines output and inflation.

2.3 The optimal interest rate

To determine each policymaker's optimal interest rate, it suffices to notice that the model is fully symmetric around zero. Therefore, the expected inflation rate can only be equal to zero. For each local Governor, the preferred policy is therefore obtained by minimizing his/her loss function over $i_{i,t}$,while assuming that the expected inflation rate is equal to zero. The optimal interest rate from the point of view of country i's representative then reads:

$$i^*_{j,t} = \frac{1}{\alpha}\gamma_{j,t} - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\beta^2)}\eta_{j,t} + \frac{1}{\alpha}\varepsilon_t - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\beta^2)}\upsilon_t \tag{9}$$

One can see that the governor j's optimal interest rate depends on two types of shocks. Namely, $\eta_{j,t}$ and $\gamma_{j,t}$ are idiosyncratic, whereas υ_t and ε_t affect the whole union. It will therefore be more convenient to consider that $i^*_{j,t}$ is the sum of a country-specific shock, $V_{j,t}$, and of a union-wide shock, U_t, such that:

$$i^*_{j,t} = U_t + V_{j,t} \tag{10}$$

where $U_t \equiv \frac{1}{\alpha}\varepsilon_t - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\alpha\beta^2)}\upsilon_t$ and $V_{j,t} \equiv \frac{1}{\alpha}\gamma_{j,t} - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\alpha\beta^2)}\eta_{j,t}$.

[4] By contrast, Montoro (2007) and Riboni and Ruge-Murica (2006) assume that committee members have different preferences, but are interested in implementing the optimal policy for the same economy.

[5] Note that, as we are interested solely in computing the variances of our results in the following sections, this simplification about the deterministic components is inocuous, while simplifying the algebra.

This notation does not prevent the two composite shocks from having well-defined expected values and variances. They are indeed both normally distributed with a zero mean and variances: $\sigma_U^2 = \frac{1}{\alpha^2}\sigma_\varepsilon^2 + \frac{(1+\lambda\alpha\beta)^2}{\alpha^2(1+\lambda\alpha\beta^2)^2}\sigma_\upsilon^2$, and $\sigma_V^2 = \frac{1}{\alpha^2}\sigma_\gamma^2 + \frac{(1+\lambda\alpha\beta)^2}{\alpha^2(1+\lambda\alpha\beta^2)^2}\sigma_\eta^2$, respectively.

The expression of $i_{j,t}^*$ above defines the interest rate that seems optimal to country j's governor. This is the interest rate that that governor would choose to implement if monetary policy was independently decided. However, in a monetary union, this is not necessarily the interest rate that will be set. On the contrary, the existence of idiosyncratic shocks implies that governors' optimal rates always differ from each other. Governors can then be expected to defend their country's or region's interest, as Meade and Sheets (2005) observed for the FOMC and Heinemann and Huefner (2004) for the ECB, whereas a single interest rate must be chosen for the whole zone, as Pollard (2003) illustrates for the ECB and the Fed. Therefore, compromises have to be found and they depend on the monetary committee's decision mechanism. The following sections investigate the implications of a variety of decision mechanisms on the implemented policy rate.

3 Hegemony

The simplest decision mechanism is to cede to one of the governors the right to set the interest rate for the whole zone. This corresponds to what Eichengreen (1995a) refers to as a hegemon. However, the hegemon may use its power in two opposite ways. First she could use it at her own benefit and maximize her own utility. This is what we refer to as a nationalist hegemon, because she focuses on minimizing her own country's losses. Second, the hegemon may also adopt a higher view and maximize the whole union's utility. This is what we call a federalist hegemon. Those two polar cases are studied in turn in the two following paragraphs.

3.1 A nationalist hegemon

By definition, a nationalist hegemon sets the common monetary policy by choosing the interest rate that best suits her own economy. A recent historic example that is particularly relevant for the European Union is the way the European Monetary System used to be managed before the adoption of the euro, as Herz and Röger (1992) suggest. In that system of fixed parities, all countries adapted their interest rates to defend the parity of their national currencies vis-à-vis the German mark. The German central bank on the other hand had almost full freedom to set the interest rate that best suited the German economy. Although that way of managing the EMS was freely accepted by the other members of the system, it corresponds to a hegemonic decision mechanism where a single country concentrates all the system's decision power. It is a consequence of the well-known $n+1$ phenomenon all systems of fixed exchange rates know (see Eichengreen, 1995b).

In our framework, a hegemonic decision mechanism allows the hegemon, country h's representative, to set her interest rate at the level she prefers, regardless of the situation of her partners. She therefore implements the interest rate that is given by the expression of $i^*_{j,t}$ above. As we are interested in the volatility of interest rates, we focus on the variance of the chosen interest rate. From above, it appears that the variance of the interest rate is simply the sum of the variances of the common shock and of the shock that is specific to the hegemon. It therefore amounts to:

$$\begin{aligned} var(i^H) &= var(i^*) = \sigma_U^2 + \sigma_V^2 \\ var(i^H) &= \frac{1}{\alpha^2}\sigma_\varepsilon^2 + \frac{(1+\lambda\alpha\beta)^2}{\alpha^2(1+\lambda\beta^2)^2}\sigma_\upsilon^2 + \frac{1}{\alpha^2}\sigma_\gamma^2 + \frac{(1+\lambda\alpha\beta)^2}{\alpha^2(1+\lambda\beta^2)^2}\sigma_\eta^2 \qquad (11) \end{aligned}$$

The above expression is the benchmark against which the other decision mechanisms will be weighed. Besides, one may also remark that it also corresponds to the variance of the interest rate that a member country's central bank would implement if her monetary policy was independent.

When deriving the welfare implications of the hegemon's policy, one has to distinguish the hegemon's welfare from the welfare of the other members of the union. To do so, the first step is to plug the actual value of the interest rate set by the hegemon in her equilibrium inflation rate and output. This gives:

$$\pi_{h,t}^H = -\frac{\lambda\beta}{1+\lambda\beta^2}\left(\eta_{h,t} + \upsilon_t\right) \qquad (12)$$

$$y_{h,t}^H = \frac{1}{1+\lambda\beta^2}\left(\eta_{h,t} + \upsilon_t\right) \qquad (13)$$

As the hegemon's expected losses are the weighted average of the variance of inflation and output, one can write:[6]

[6] Recall that the quadratic loss functions that describe governors' preferences imply that their expected losses simply amount to the weighted sum of the variances of inflation and output. Namely, $E(G_i) = \frac{1}{2}var(\pi_i) + \frac{\lambda}{2}var(y_i)$.

$$var(\pi_h^H) = -\frac{\lambda^2\beta^2}{(1+\lambda\beta^2)^2}\left(\sigma_\eta^2 + \sigma_\upsilon^2\right) \tag{14}$$

$$var(y_h^H) = \frac{1}{(1+\lambda\beta^2)^2}\left(\sigma_\eta^2 + \sigma_\upsilon^2\right) \tag{15}$$

$$E(G_h^H) = \frac{\lambda}{2}\frac{1}{1+\lambda\beta^2}\left(\sigma_\eta^2 + \sigma_\upsilon^2\right) \tag{16}$$

It thus turns out that the hegemon's welfare is only affected by the idiosyncratic supply shock and the common demand shock, the other two shocks being completely absorbed. Here again, one can also interpret the above expression as describing a single independent country's welfare.

Now, what is true for the hegemon or an independent country is not necessarily true for the other members of the union. Indeed, it can be seen from the hegemon's reaction function that the idiosyncratic shocks in the other economies are not taken into account. The expressions of their output and inflation rate are thus obtained by plugging the hegemon's optimal interest rate in expressions (3a, b, c). One then gets:

$$\pi_{j,t}^H = \frac{-1}{\beta-\alpha}\gamma_{h,t} + \frac{1}{\beta-\alpha}\frac{1+\lambda\alpha\beta}{1+\lambda\beta^2}\eta_{h,t} + \frac{1}{\beta-\alpha}\gamma_{j,t} - \frac{1}{\beta-\alpha}\eta_{j,t} - \frac{\lambda\beta}{1+\lambda\beta^2}\upsilon_t \tag{17}$$

$$y_{j,t}^H = \frac{-\beta}{\beta-\alpha}\gamma_{h,t} + \frac{\beta}{\beta-\alpha}\frac{1+\lambda\alpha\beta}{1+\lambda\beta^2}\eta_{h,t} + \frac{\beta}{\beta-\alpha}\gamma_{j,t} - \frac{\alpha}{\beta-\alpha}\eta_{j,t} + \frac{1}{1+\lambda\beta^2}\upsilon_t \tag{18}$$

These expressions are meaningful when compared to those that describe the hegemon's situation. Output and inflation in other member countries are affected by five types of shocks instead of two, which is the case for the hegemon. True, other countries benefit from the full absorption of the common demand shock and the partial accommodation of the common supply shock, but their domestic supply and demand shocks are left unabsorbed. In addition, they have to bear the hegemon's domestic shocks that are passed onto them through the interest rate.

We can also obtain the other members'welfare result in the same way as the hegemon's. Namely:

$$var(\pi_j^H) = \frac{1}{(\beta-\alpha)^2}\left[\sigma_\gamma^2 + \left(\frac{1+\lambda\alpha\beta}{1+\lambda\beta^2}\right)^2 \sigma_\eta^2\right] + \frac{1}{(\beta-\alpha)^2}\left[\sigma_\gamma^2+\sigma_\eta^2\right] + \frac{\lambda^2\beta^2}{\left(1+\lambda\beta^2\right)^2}\sigma_\upsilon^2 \tag{19}$$

$$var(y_j^H) = \frac{\beta^2}{(\beta-\alpha)^2}\left[\sigma_\gamma^2 + \left(\frac{1+\lambda\alpha\beta}{1+\lambda\beta^2}\right)^2 \sigma_\eta^2\right] + \frac{1}{(\beta-\alpha)^2}\left[\beta^2\sigma_\gamma^2+\alpha^2\sigma_\eta^2\right] + \frac{1}{\left(1+\lambda\beta^2\right)^2}\sigma_\upsilon^2 \tag{20}$$

$$E(G_j^H) = \frac{1}{2(\beta-\alpha)^2}\left[\left(1+\lambda\beta^2\right)\sigma_\gamma^2 + \frac{(1+\lambda\alpha\beta)^2}{1+\lambda\beta^2}\sigma_\eta^2\right] + \frac{1}{2(\beta-\alpha)^2}\left[\left(1+\lambda\alpha^2\right)\sigma_\gamma^2 + \left(1+\lambda\beta^2\right)\sigma_\eta^2\right] + \frac{\lambda}{2\left(1+\lambda\beta^2\right)}\sigma_\upsilon^2 \tag{21}$$

Those expressions show that there are three sources of disturbances for member countries' economies, hence three sources of losses. That is, each country faces its own shocks, the hegemon's reaction to her own shocks, and some of the common supply shock. Consequently, the hegemon is definitely better off than her fellow member countries.

3.2 A federalist hegemon

The federalist hegemon is interested not in the situation of any country in particular but in the union's welfare as a whole. Such a hegemon's preferences are then described by the following loss function:

$$G_t^F = \frac{1}{2}\left(\pi_t^f - \pi^*\right)^2 + \frac{\lambda}{2}\left(y_t^f - y^*\right)^2 \tag{22}$$

She minimizes this loss function under the constraint of the expressions in (5a, b), which determines the union's inflation rate and output level. In this case, the first order condition leads to the following optimal interest rate:

$$i_t^F = \frac{1}{\alpha}\varepsilon_t - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\alpha\beta^2)}\upsilon_t \tag{23}$$

The federalist hegemon only reacts to the unionwide shocks, simply because she does not care for members' idiosyncrasies. This is why the interest rate she implements is only a function of the union's common demand and supply shocks. The variance of the resulting interest rate is accordingly given by:

$$var\left(i^F\right)=\frac{1}{\alpha^2}\sigma_\varepsilon^2+\frac{\left(1+\lambda\alpha\beta\right)^2}{\alpha^2(1+\lambda\alpha\beta^2)^2}\sigma_\upsilon^2 \tag{24}$$

It is straightforward to observe from the above expression that the variance of the interest rate set by a federalist hegemon is lower than the variance of the interest rate set by a nationalist hegemon.

By plugging that interest rate in the expression of each country's inflation rate and output level, one can describe the impact of the federal policy on the economies of union members:

$$\pi_{j,t}^F=\frac{1}{\beta-\alpha}\gamma_{j,t}-\frac{1}{\beta-\alpha}\eta_{j,t}-\frac{\lambda\beta}{1+\lambda\beta^2}\upsilon_t \tag{25}$$

$$y_{j,t}^F=\frac{\beta}{\beta-\alpha}\gamma_{j,t}-\frac{\alpha}{\beta-\alpha}\eta_{j,t}+\frac{1}{1+\lambda\beta^2}\upsilon_t \tag{26}$$

The variances of the inflation rate and the output level of member countries can be easily derived, which subsequently allows us to write their expected losses:

$$var(\pi_j^F)=\frac{1}{\left(\beta-\alpha\right)^2}\left(\sigma_\gamma^2+\sigma_\eta^2\right)+\frac{\lambda^2\beta^2}{\left(1+\lambda\beta^2\right)^2}\sigma_\upsilon^2 \tag{27}$$

$$var(y_j^F)=\frac{1}{\left(\beta-\alpha\right)^2}\left(\beta^2\sigma_\gamma^2+\alpha^2\sigma_\eta^2\right)+\frac{1}{\left(1+\lambda\beta^2\right)^2}\sigma_\upsilon^2 \tag{28}$$

$$E(G_j^F)=\frac{1}{2\left(\beta-\alpha\right)^2}\left[\left(1+\lambda\beta^2\right)\sigma_\gamma^2+\left(1+\lambda\alpha^2\right)\sigma_\eta^2\right]+\frac{\lambda^2\beta^2}{2\left(1+\lambda\beta^2\right)^2}\sigma_\upsilon^2 \tag{29}$$

Comparison of (12a, b, c) and (18a, b, c) reveals that member countries are better off under the rule of a federalist hegemon than under a nationalist's. They are affected in the same way by common shocks and their own idiosyncratic shocks but they do not have to cope with the hegemon's reaction to her own idiosyncratic shocks.

4 Democracy

We now turn to more democratic decision-making mechanisms, which share the union's decision power over monetary policy. The first case assumes that the governors bargain over the implemented rate. Specifically, we consider that the resulting interest rate can be obtained as the outcome of a Nash bargaining. We then focus on the consensus, or averaging, rule. Third, we examine majority voting.

4.1 Nash bargaining

The interest rate that results from a Nash bargaining is equivalent to the one that would result from the minimization of a composite loss function consisting in the weighted sum of the members' loss functions. As we assume that all members are of equal size, it is also reasonable to assume that their weights are equal.[7] Therefore, the Nash bargaining solution is equal to the interest rate that minimizes the following loss function:

$$N_t = \sum_{j=1}^{n} \left(\frac{1}{2}\pi_{j,t}^2 + \frac{\lambda}{2} y_{j,t}^2 \right) \tag{30}$$

where the individual inflation rate and output are respectively given by expressions (3a) and (3b).

After tedious but simple algebra displayed in the appendix, the first order condition leads the following optimal value for the interest rate that results from a Nash bargaining:

$$i_t^N = \frac{1}{\alpha}\varepsilon_t - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\alpha\beta^2)}\upsilon_t \tag{31}$$

In other words, the Nash bargaining solution results in the interest rate reacting to unionwide shocks only. Asymmetric shocks are not taken into account because they cancel out in the negotiation process. The volatility of the interest rate set by a committee that bargains over monetary policy is therefore the same as that of an interest rate set by a federalist hegemon. It is therefore also lower than the volatility of the interest rate set by a nationalist hegemon.

One easily notices that the interest rate determined after a Nash bargaining is the same as the one that a federalist hegemon would choose. The reasons why they both only depend on unionwide shocks however differ. As mentioned above, the federalist hegemon only reacts to unionwide shocks because she simply cares for no specific member country. In the case of a Nash bargaining each governor only cares for her own country. However country-specific shocks cancel out in the bargaining process. Therefore only common disturbances are tackled.

A corollary of this result is that the variance of the interest rate determined in a Nash bargaining is equal to the variance of the interest rate set by a federalist hegemon, as defined by expression (18c).

[7] Note that we rule out coalitions in our setting, as countries are of the same size and have the same kind of preferences.

The resulting inflation rates and output levels are therefore given by the expressions in (17a, b). Their variances and members' expected losses are thus the same as in (18a, b).

4.2 Consensus rule

Instead of bargaining, committee members can decide to try to find a consensus. This is in particular the decision rule officially used in the Fed's and the ECB's governing bodies. Formally, this decision rule can be assumed to implement the average of the committee members' interest rates. This is why it is also referred to as the averaging rule in the literature as for instance in Matsen and Røisland (2005).

In that case, the chosen rate can be written as:

$$i_t^C = \frac{1}{n}\sum_{j=1}^{n} i_{j,t}^* \tag{32}$$

When replacing $i_{j,t}^*$ by its value in the above expression and rearranging it, it becomes:

$$i_t^C = \frac{1}{n}\sum_{j=1}^{n}\left[\frac{1}{\alpha}\varepsilon_t - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\alpha\beta^2)}\upsilon_t\right] + \frac{1}{n}\frac{1}{\alpha}\sum_{j=1}^{n}\gamma_{j,t} - \frac{1}{n}\frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\alpha\beta^2)}\sum_{j=1}^{n}\eta_{j,t}$$

which boils to the following expression since the sums of domestic supply and demand shocks are assumed to be zero:

$$i_t^C = \frac{1}{\alpha}\varepsilon_t - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\alpha\beta^2)}\upsilon_t \tag{33}$$

This expression of the interest rate is the same as the one that describes the result of a Nash bargaining. There is therefore nothing that bargaining can achieve that consensus cannot achieve as well. All the results that apply to the former equally apply to the latter, in particular those that pertain to the ranking of the variances of the interest rate under various decision rules.

4.3 Majority voting

Unlike the Fed or the ECB, other banks, like the Bank of England, resort to majority voting (see Cobham, 2003). Although it has never resorted to such a decision mechanism, the ECB's governing council can officially resort to majority voting, as provided for by article 10 of the ECB statute. To formalise this decision mechanism, let us now assume that all governors can cast one equally weighted vote, which is consistent with our assumption that all countries are of equivalent size.

Under those circumstances, the median voter theorem applies, since preferences are single peaked in terms of the interest rate. Therefore, the governor whose optimal interest rate corresponds to the median of the optimal interest rates of all the members of the committee can build a coalition that defeats any interest rate that is not his favourite one. The implemented interest rate is therefore equal to the interest rate that minimizes the median governor's loss function, as given by expression (7), which we note i^M. Thus:

$$\begin{aligned} i_t^M &= median\left[i_t^1, ..., i_t^n\right] \\ &= \frac{1}{\alpha}\varepsilon_t - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\beta^2)}\upsilon_t + \frac{1}{\alpha}M_t \end{aligned} \tag{34}$$

where $M_t = median\left[\gamma_{j,t} - \frac{1+\lambda\alpha\beta}{(1+\lambda\alpha\beta^2)}\eta_{j,t}\right]$.

Unlike in usual applications of the median voter theorem, here the identity of the median voter changes over time, due to the fact that each governor's optimal interest rate is subject to random shocks. A simplification would be to consider that the number of committee members is infinite. The median interest rate would consequently always be equal to the mean. To be sure, this assumption would simplify the analysis but would also substantially affect its results. As long as n is not infinite, the median depends on the realization of individual shocks. We must therefore investigate in details the stochastic properties of i^M.

First, the expected value of i_t^M is equal to the mean of all $i_{j,t}^*$'s. As we assume that idiosyncratic shocks cancel out at the federal level, the mean of $i_{j,t}^*$'s is therefore equal to the common shock, U_t. As we are interested in the volatility of the interest rate, we must bear in mind that governors' favourite outcomes are subject to two shocks. The first one, U_t, affects the mean of favourite interest rates. The second one, $V_{j,t}$, affects the distribution of governors' favourite policies around that mean. Since U_t and $V_{j,t}'$s are orthogonal, the variance of the chosen value of i_t^M is therefore the sum of the variance of U_t and of the variance of the median of a sample drawn from the distribution of $V_{j,t}$[8]. It therefore reads:[9]

[8]The interested reader can refer to Kenney and Keeping (1962). It must be said that expression of $Var(i^M)$ rests on the expression of the variance of a large sample's median. Although no such expression exists for the variance of the median of a small sample, the estimates provided by Maritz and Jarrett (1978) show that our results can be extended to small samples. They therefore hold for small and large monetary unions.

[9]For clarity's sake, please notice that π (as opposed to $\pi_{j,t}$) refers to the mathematical constant, and not to inflation.

$$var(i^M) = \sigma_U^2 + \frac{\pi}{2n}\sigma_V^2$$
$$var(i^M) = \frac{1}{\alpha^2}\sigma_\varepsilon^2 + \frac{(1+\lambda\alpha\beta)^2}{\alpha^2(1+\lambda\beta^2)^2}\sigma_\upsilon^2 + \frac{\pi}{2n}\left[\frac{1}{\alpha^2}\sigma_\gamma^2 + \frac{(1+\lambda\alpha\beta)^2}{\alpha^2(1+\lambda\beta^2)^2}\sigma_\eta^2\right] \tag{35}$$

This expression leads to several interesting insights on the way a monetary committee may manage interest rates. At first glance it appears that the variance of the interest rate is a positive function of the variance of both common and idiosyncratic shocks. Unsurprisingly, the more volatile the economies of which the union consists, the more volatile is the interest rate.

It furthermore appears that the volatility of the interest rate is a decreasing function of the number of economies that partake in the union. The rationale for this result stems from the fact that the outcome of the decision process is the median of the favourite interest rates of the members of the committee. To be sure, the median can be quite different from the mean. This is precisely why the interest rate is volatile. However, the median governor can by definition never be the extreme governor. Majority voting therefore prevents extreme idiosyncratic shocks from influencing the outcome of the vote.

Furthermore, as the number of countries increases, idiosyncratic shocks tend to be more and more evenly distributed around the mean. The median governor's favourite interest rate is therefore likely to be closer to the mean. This effect explains the negative relationship between the monetary union's size and the volatility of the interest rate.

This rationale is however not applicable to union-wide shocks. The above expression underlines that the variance of the outcome of the vote is greater than or equal to the variance of U_t. In a union whose size would be infinite, or that would be perfectly homogeneous, namely if $\sigma_V^2 = 0$, the number of participating countries would not affect chosen policies. In other words, $var(i^M)$ would be equal to $var(i^*)$.

Another substantial finding stems from the comparison between the policy of a nationalist hegemon and the policy chosen by majority voting in the committee. Simple comparison of the two expressions for i^* and i^M reveals that the latter leads to less volatility in the interest rate. This is a consequence of the fact that majority voting limits the influence of extreme country-specific shocks. On the contrary a hegemon can be hit by an extreme shock.[10] The interest rate set by a hegemon can therefore

[10] German reunification is but one example of an extreme shock that hit a hegemon, who set its monetary policy accordingly.

take extreme values. Overall, the variance of the interest rate set by a hegemon is consequently larger than the variance of the interest rate set by a committee. This comes at a cost for the hegemon, but benefits all its partners.[11]

On the other hand, the volatility of the interest rate set by majority voting is greater than the volatility of the interest rate set either by a federalist hegemon, by consensus, or through Nash bargaining. The intuition for that result is that monetary policy accommodates the shocks that hit the median country. These cannot by construction be extreme shocks but they can be different from the mean of the idiosyncratic shock, here zero. The interest rate must therefore vary to accommodate them.

As before, the consequences of majority voting for individual members in terms of inflation and output can be derived by replacing the implemented interest rate by its value in the expression of members' inflation and output. This gives:

$$\pi_{j,t}^{M} = \frac{1}{\beta - \alpha}\left[\gamma_{j,t} - \eta_{j,t} - M_t\right] - \frac{\lambda\beta}{1+\lambda\beta^2}\upsilon_t \tag{36}$$

$$y_{j,t}^{M} = \frac{\beta}{\beta - \alpha}\left[\gamma_{j,t} - \frac{\alpha}{\beta}\eta_{j,t} - M_t\right] + \frac{1}{1+\lambda\beta^2}\upsilon_t \tag{37}$$

It can thus be seen that majority voting among governors allows to fully offset common demand shocks and to absorb common supply shocks to the same extent as the one that would be obtained by an independent country. However, the extent to which asymmetric shocks are absorbed depends on the extent to which each country can affect the median of optimal interest rates. This results in the following expressions for the variance of output and inflation, and for expected losses:

[11] Here again, the prospect of sharing the Bundesbank's decision power appeared as a key benefit of monetary union to non-German members of the EMS, as stated in Bini-Smaghi et al. (1994).

$$
\begin{aligned}
var(\pi_j^M) &= \frac{1}{(\beta-\alpha)^2}\left[var\left(M_t\right)+\sigma_\gamma^2+\sigma_\eta^2-2cov\left(M_t,\gamma_{j,t}\right)+2cov\left(M_t,\eta_{j,t}\right)\right] \\
&+\frac{\lambda^2\beta^2}{\left(1+\lambda\beta^2\right)^2}\sigma_\upsilon^2 \qquad (38) \\
var(y_j^M) &= \frac{\beta^2}{(\beta-\alpha)^2}\left[var\left(M_t\right)+\sigma_\gamma^2+\frac{\alpha^2}{\beta^2}\sigma_\eta^2-2cov\left(M_t,\gamma_{j,t}\right)+2\frac{\alpha}{\beta}cov\left(M_t,\eta_{j,t}\right)\right] \\
&+\frac{1}{\left(1+\lambda\beta^2\right)^2}\sigma_\upsilon^2 \qquad (39) \\
E(G_j^M) &= \frac{1}{2\left(\beta-\alpha\right)^2}\left[\left(1+\lambda\beta^2\right)^2 var\left(M_t\right)+\left(1+\lambda\beta^2\right)^2\sigma_\gamma^2+\left(1+\lambda\alpha^2\right)^2\sigma_\eta^2\right] \\
&+\frac{1}{2\left(\beta-\alpha\right)^2}\left[-2\left(1+\lambda\beta\right)cov\left(M_t,\gamma_{j,t}\right)+2\left(1+\lambda\alpha\beta\right)cov\left(M_t,\eta_{j,t}\right)\right] \\
&+\frac{\lambda}{2\left(1+\lambda\beta^2\right)}\sigma_\upsilon^2 \qquad (40)
\end{aligned}
$$

When the variance of M_t and its covariances with $\gamma_{j,t}$ and $\eta_{j,t}$ are replaced by their expressions, one obtains interpretable expressions of the variances of members' inflation rates and outputs, and of their expected losses.

$$
\begin{aligned}
var(\pi_j^M) &= var(\pi_j^N) \\
&+\frac{1}{2n}\frac{1}{(\beta-\alpha)^2}\left[(\pi-2)\sigma_\gamma^2+\frac{1+\lambda\alpha\beta}{1+\lambda\beta^2}\left(\pi\frac{1+\lambda\alpha\beta}{1+\lambda\beta^2}-2\right)\sigma_\eta^2\right] \\
&\qquad (41) \\
var(y_j^M) &= var(y_j^N) \\
&+\frac{1}{2n}\frac{\beta^2}{(\beta-\alpha)^2}\left[(\pi-2)\sigma_\gamma^2+\frac{1+\lambda\alpha\beta}{1+\lambda\beta^2}\left(\pi\frac{1+\lambda\alpha\beta}{1+\lambda\beta^2}-2\frac{\alpha}{\beta}\right)\sigma_\eta^2\right] \\
&\qquad (42) \\
E(G_j^M) &= E(G_j^N) \\
&+\frac{\pi-2}{2n}\frac{1}{(\beta-\alpha)^2}\left[(1+\lambda)\sigma_\gamma^2+(1+\lambda\alpha\beta)^2\sigma_\eta^2\right] \qquad (43)
\end{aligned}
$$

Expressions (27a, b, c) reveals that the variance of both inflation and output, as well as each member's losses, are greater under majority rule than under other democratic rules. This apparently surprising result can be explained intuitively by referring to the basic expressions of output and inflation, and to the statistical properties of the median of domestic shocks.

Let us for instance focus on output, although the same line of reasoning applies to the variances of inflation and, as a result, to expected losses. Namely, country i's output is a function of the common interest rate, which is itself the median of all countries' optimal interest rate. On the one hand, this implies that the agreed upon interest rate can sometimes address country i's shocks. This possibility depends on the covariance of the median interest rate with each country's domestic shocks, as expression (27b) underlines. On the other hand, as the median optimal interest rate is more volatile than the interest rate set with other rules, majority voting therefore creates extra volatility, which increases the variance of each country's output.

Indeed, as expression (27c) shows, the second effect more than compensates the former.[12] Majority voting therefore results in an increase in each country's output volatility with respect to other democratic rules and to the federal rule. By the same token, it also raises the variance of inflation, hence expected losses, since they are simply a weighted sum of both variances.

Rather ironically, majority voting results in greater policy rate volatility than most other rules described so far, but that greater volatility results neither in greater monetary and real stability nor in greater welfare.

We can now rank decision rules in terms of implied volatility and welfare. Being a hegemon provides the lowest volatility of output and inflation and the lowest expected losses. At the same time, living under the rule of a nationalist hegemon leads to the greatest volatility of inflation and output and the largest expected losses. Between those two extremes stand living under the rule of a federalist hegemon or setting monetary policy thanks to a consensus rule. Then comes majority voting. Those results however so far rest on a set of decision rules where all countries, except the hegemon herself, assume symmetric roles. The next section investigates more realistic mechanisms, where roles inside the committee can be asymmetric.

5 Enter Chairman

Until now, we have considered a policy committee composed of only one type of agent, i.e. national representatives. Nevertheless, it is quite common for a committee to be headed by a chairman. This feature

[12] In statistical terms, this results from the fact that the median is less efficient but more robust an estimator than the mean. In other words, it is more volatile than the mean, but less sensitive to the value of any specific observation at the same time.

can not be disregarded, especially as Chappell et al. (2004, 2005) have estimated the chairman's weight in the Fed's decisions to be close or superior to 50%.[13] To be more realistic, we therefore have to take into account the chairman's influence on policy committee meetings. Positions in the council consequently become asymmetric since a single chairman faces all the other members of the committee. The impact of that institutional feature however depends on the chairman's objectives. Two situations can however be considered. First, the chairman may be chosen among the other committee members, and be a "primus inter pares" who minimizes her country's losses. Second, the chairman may take on a union-wide view and follow federal objectives. Both cases are nested in the same theoretical analysis. In this section, we therefore first provide a formal description of decision-making with a chairman, then investigate the properties of that decision mechanism with a nationalist or a federalist chairman.

5.1 The chairman's behaviour

Regardless of her objective, we assume that the chairman's role is to be the committee meetings' agenda setter, as Pollard (2003) reports for the ECB and the Fed. In the context of our model, this means that she submits to other committee members an interest rate that they may accept or reject by majority voting. In such set-ups, it is usually assumed that the proposal is implemented immediately if it is accepted, and that the status quo prevails until the next vote if it is not (see Romer and Rosenthal, 1978, or Primo, 2002, for recent elaborations).[14]

Since the chairman is the agenda setter, she enjoys an extra influence on the committee's decisions. However, committee members have no obligation to agree upon the proposed interest rate. Indeed, they can always vote it down if they prefer the status quo instead. The chairman's strategy is therefore to submit the interest that is closest to her optimum, given the threat of having it voted down if the committee prefers the status quo. The implemented policy thus depends on the agenda setter's favourite policy but also on the outcome of the vote, that is on the median voter's favourite policy.

To apply this representation of decision making to our model, let us label i_t^P the chairman's interest proposal, and assume, without loss of generality, that the status quo is given by a zero interest rate, which

[13] See Blinder and Morgan (2007) for experimental evidence on this point.

[14] Assuming a single governor is a simplification for some central banks. In the case of the ECB, for example, the Board includes six members who are appointed to represent the whole Euro-area's interests, and are therefore expected to pursue federal objectives.

in our model corresponds to the average interest rate inherited from the previous period. Let us denote the preferred level of the policy decision by the agenda-setter and the median value of those of committee members respectively by i_t^A and i_t^M. The proposing action of the agenda-setter is represented by function $i_t^P = A(i_t^A\ ;\ i_t^M)$, as in Grossman and Helpman (2001). Now, depending on the value of the chairman's and the median voter's favourite interest rates, three cases, which are represented below, can emerge.

First, if the chairman's optimal interest rate is close enough to the median voter's optimum and far enough from the status quo, she will be able to propose her favourite interest rate and have it accepted by the committee. This follows from the fact that the status quo will be costlier to the median voter than the proposed interest rate.

Second, if the chairman's optimal interest rate and the median voter's lie on opposite sides of the status quo, then the best proposal that the chairman can make is precisely the status quo. The median voter will indeed turn down any proposed interest rate that is closer to the chairman's favourite interest rate. The status quo will then prevail.

The third case is intermediate. Namely, the chairman may be able to avoid the status quo without being able to impose its favourite interest rate. In that case, i_t^A is so far off from the status quo, in relation to i_t^M, that the distance between i_t^A and 0 is at least twice as long as the distance between i_t^M and 0. Since the committee will vote down all the proposals whose distance from the status quo is larger than $2i_t^M$, the best proposal for the agenda-setter is $i_t^P = 2i_t^M$. This proposed interest rate is still preferred by the chairman to the status quo, even though it is different from her favourite interest rate, and will pass the vote among the committee members.

However, in all cases, the agenda setter's proposal constitutes an equilibrium value of the interest rate for the current period , i.e. $i_t = i_t^P$, as all of those proposals will succeed in the majority vote within the committee. To sum up, the interest rate implemented by a committee with a chairman is given by the following rule:[15]

[15] The possibility of a status quo had not appeared in the previous section. However, if we complement the model by the assumption that the interest rate must follow a step pattern, like in Gerlach-Kristen (2005), this possibility is introduced in the model for all decision rules. In that case, committees can be shown to raise the probability of a status quo, each time the optimal interest rate variation is inferior to the increment size. Moreover, in the case of majority voting, the probability of a status quo increases with the number of policy-makers in the committee.

$$\begin{cases} i_t = i_t^A & iff \quad 2i_t^M > i_t^A > 0 \quad or \quad 2i_t^M < i_t^A < 0 \\ i_t = 0 & iff \quad i_t^M < 0 < i_t^A \quad or \quad i_t^M > 0 > i_t^A \\ i_t = 2i_t^M & iff \quad i_t^A > 2i_t^M > 0 \quad or \quad i_t^A < 2i_t^M < 0 \end{cases} \tag{44}$$

The above rule is the same regardless of the chairman's objective. Now, depending on her objective, her favourite interest rate will differ, depending on wether she defends her own country's interest or adopts a federalist view. We investigate both cases in the next subsection.

5.2 Outcomes with chairmen

To investigate the impact of the existence of a chairman, one should replace i_t^A by the relevant interest rate in the above policy rule. One can then infer the variance of the chosen interest rate, of the inflation and output, as well as the implied expected losses. However, due to the complexity of the decision rule, no closed-form expression can be found for those variables. As a consequence, we resorted to simulations. More precisely, we ran a Monte Carlo experiment to investigate the stochastic properties of i_t, y_t, π_t, and G_t. We first assumed that the chairman was a nationalist and that her favourite interest rate was given by (7). Second, we assumed that the chairman acted in a federalist way. To allow for comparison, we also investigated the properties of the other decision rules described previously. To do so, we followed Matsen and Røisland (2005) and assumed the following realistic values for the parameters: $\lambda = 1$, $\beta = 20$, $\sigma = 0.02$, and $\alpha = 0.25$. In line with the above assumption of a monetary union composed of a large number of countries, we consider a union of 30 members. We drew 1000 series of the stochastic shocks, hence estimated the properties of the parameters on 1000 observations. The results are displayed in table 1 below.

Insert **Table 1** about here

Table 1 above first allows to compare the volatility that the two kinds of chairman deliver. It thus appears that, under a nationalist chairman, the interest rate is unambiguously more volatile than under a federalist chairman. This result should not be surprising since the former's favourite interest rate was shown to be more volatile than the latter's in the previous section. More to the point, we can also compare the policy implemented by each chairman with the policy she would implement if she did not have to cope with the committee. We can thus compare the policy implemented by the nationalist chairman with that implemented by the nationalist hegemon and the policy implemented by the federalist chairman with that implemented by the federalist hegemon. It thus appears that the volatility of the interest rate implemented by the same individual is always smaller when she acts as a chairman than when she acts as a hegemon. The intuition is straightforward, since a hegemon can always implement her favourite policy whereas a chairman must accomodate her committee's will. Accordingly, a chairman must refrain from changing the interest rate to the extent she would like, which reduces its volatility.

The two committees headed by a chairman can be compared to the other decision mechanisms. It thus appears that a committee headed by a nationalist chairman delivers an interest rate whose variability lies between that of a nationalist hegemon and that of majority voting. On the other hand, a committee headed by a federalist chairman generates less volatility than a nationalist chairman, and is thus the least activist of all decision mechanisms.

Now, those policies affect the volatility of the economies of member countries differently and result in different levels of expected losses. Rankings are the same, regardless of the variable considered, which allows to save on space. Thus, table 1 shows that the decision mechanism that results in the least macroeconomic volatility and the smallest expected losses is being a hegemon. Compared to that situation, chairing the monetary policy committee results in a sizeable increase in one's economy's volatility and expected losses, but is still preferable to participating in a union governed by a federalist hegemon or governed by the consensus or bargaining rules. Majority is the following decision mechanism in terms of macroeconomic volatility and expected losses, closely followed by being ruled by a federalist chairman.[16] The latter is however better than living under the rule of a committee headed by a nationalist chairman when the chairman is not a fellow citizen. Finally, the worst situation is that of countries that live under the rule of a nationalist hegemon. The next section investigates whether they are also robust to asymmetries among members of the union.

5.3 Outcomes in an asymmetric union

In the previous sections, the only asymmetries that were allowed pertained to the governors' roles in the decision mechanisms. This simplification allowed us to get closed-form solutions for the outcomes of those rules but is not very appealing empirically. This is why we now consider asymmetries among members of the union. To do so, we again follow Matsen and Røisland (2005), and assume that the main difference between countries pertains to the elasticity of aggregate demand to the

[16] This result may help explain why it is so rare that chairmen of monetary policy committees are voted down (see Cobham, 2003, and Chappell et al., 2004, 2005).

real interest rate, that is α. From Ehrmann et al. (2003), we could get estimates of that parameter for nine countries that presently participate in the European monetary union. We then used those estimates to investigate the outcome for each member of the various decision rules we have described, thanks to the same Monte Carlo experiment as above. To save on space, we did not consider every possible hegemon and chairman cases. Instead, we focused on arbitrary but somewhat historically meaningful instances. Thus, the nationalist hegemon was assumed to be Germany, which can be interpreted as representing the way decision power was allocated in the European Monetary System before monetary union. We also considered two possible nationalist chairmen, namely a Dutch and a French, to relate our findings to Wim Duisenberg's and Jean-Claude Trichet's mandates. The estimated interest rate volatilities are displayed in table 2 below, where decision rules are ranked by order of increasing interest rate volatility.

Insert **Table 2** about here

Several key findings appear in table 2. First, whereas bargaining and a federalist hegemon deliver the same outcome in a symmetric union, they lead to different interest rate volatilities when asymmetries are introduced. Now, bargaining results in less volatility than a federal hegemon, which in turn delivers less volatility than the consensus rule.

Second, when the committee is headed by a nationalist chairman, the variance of the interest rate depends on her country of origin: a French chairman engineers three and a half times as much interest rate volatility as a Dutch one in our model. This results from the fact that the elasticity of the Dutch output to the real interest rate is two and a half times larger than the French, which implies that the variance of the French optimal interest rate is almost six times larger than the variance of the Dutch one.

Finally, one can now rank decision rules in terms of the interest rate volatility they imply: a Dutch presidency results in the smallest variance of the common interest rate. It is followed by bargaining, a federalist chairman, a federalist hegemon, majority voting, the consensus rule, and a French presidency. The decision rule that leads to the largest variance of the interest rate is German hegemony.[17] It thus appears that the asymmetries we have introduced in our reasoning slightly modify but do

[17] Recall that we consider that all governors share the same relative aversion for output fluctuations, because we have no estimates of λs. Estimated volatilities may well differ if one allowed for differences in that parameter. In particular, a German hegemon may rank differently if one allowed her to be more inflation averse than her colleagues.

not completely shuffle the ranking of decision rules in terms of implied interest rate volatility.

Now, if one wishes to compare the consequences of each decision rule in terms of welfare, one has to consider each country in turn.[18] This is what table 3 below allows:

Insert **Table 3** about here

Here again, several findings appear in table 3. The first one is that the ranking of decision mechanisms in terms of expected losses differs across countries: countries that play the role of a hegemon or head the committee minimize their losses. This result is fairly intuitive since those mechanisms allow the hegemon or the chairman to steer the common monetary policy toward their needs. On the other extreme, the worst mechanism for all countries but Germany is precisely a German hegemon. This should not come as a surprise either, since this decision structure ensures that countries' shocks are never taken into account although the volatility of German shocks is transmitted to them by the interest rate.

As regards countries' favourite decision rule, that is the one that minimizes their expected losses, no single candidate stands out. However, one may summarize our results by saying that countries tend to prefer symmetric rules. Thus, bargaining is favoured by Belgium, Finland, Ireland, and the Netherlands, unless the latter chairs the union, while the consensus rule minimizes the losses of Spain, France (when it does not chair the union), Germany (unless it is the hegemon), and Italy. Finally, majority voting is Austria's favourite decision rule. In general, these three rules come in close range with the federalist chairman, whereas countries' losses tend to be greater with a nationalist hegemon, be it French or Dutch. The tables that are displayed in the appendix lead to the same conclusions, but in terms of variance of output and of the inflation rate.

6 Conclusion

This paper's key contention is that different decision rules should lead to different degrees of volatility of the policy rates. We investigated its implications thanks to a standard model of endogenous monetary policy in a monetary union where policy decisions are made by a committee consisting of representatives of member countries. We could thus determine the ranking of those rules in terms of volatility of the interest rate, in terms of macroeconomic volatility, and finally in terms of welfare.

[18] For brevity's sake, we only comment estimated expected welfare. We however provide the estimated variances of inflation and output in the appendix.

In terms of volatility of the interest rate in a symmetric union, the ranking of decision rules by order of decreasing variance of the interest rate is the following: 1. a nationalist hegemon; 2. a nationalist chairman; 3. majority voting; 4. bargaining, consensus, or a federal hegemon; 5. a federal chairman. In terms of expected welfare, the ranking is reversed except that the welfare provided by a federalist chairman slightly exceeds that of majority voting.

When asymmetries, calibrated to mimic those existing in the European Monetary Union, are introduced among members of the monetary union, the ranking of decision rules in terms of their implied volatility of the interest rate is slightly modified and then reads: 1. a nationalist hegemon; 2. consensus; 3. majority voting; 4. a federal hegemon; 5. a federal chairman; 6. bargaining. The volatility of the interest rate when it is set by a committee headed by a nationalist chairman was moreover found to be quite sensitive to her nationality. That volatility could be very small or very large depending on the volatility of the chairman's interest rate. The ranking of rules in terms of expected welfare however differs for each country.

Broadly speaking, if a country can neither be the hegemon nor appoint the committee's chairman, then it will be better off if the committee uses a symmetric decision mechanism, such as the consensus rule of bargaining.

Goodhart (1999) suspected academic models to miss something important. By taking committees and chairmen into account, this paper embedded two important features of today's central banks in the theory of monetary policy-making. However, more work still needs to be done, with several potential extensions. First, other decision rules can be investigated. We restricted ourselves to the most common ones here, but the literature is full of more subtle decision making mechanisms such as, for instance, weighted votes or rotation. Second, the structural model of the economy could be improved. It could in particular be made dynamic, to better describe the inertia of interest rates. Moreover, our theoretical findings could be taken to the data. There are at least two basic ways of doing this. First, the predicted volatility of the interest rate under various decision rules could be compared with the observed volatilities of the interest rates set by monetary policy committees that use those rules. Second, one may also infer the decision rule implied by the observed behaviour of the interest rate, in an attempt to determine central banks' decision rules. In any case, research on monetary policy committees is bound to go on delivering new interesting insights.

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Appendix 1.

The Nash bargaining solution is determined by the minimization of the following loss function:

$$N_t = \sum_{j=1}^{n}\left(\frac{1}{2}\pi_{j,t}^2 + \frac{\lambda}{2}y_{j,t}^2\right) \tag{45}$$

Plugging **(3*a*)** and **(3*b*)** into the above expression, one obtains:

$$N_t = \sum_{j=1}^{n}\left\{\begin{array}{c} \frac{1}{2}\left[\frac{1}{\beta-\alpha}\left(-\alpha i_t + \gamma_{j,t} - \eta_{j,t} + \varepsilon_t - \upsilon_t\right)\right]^2 \\ +\frac{\lambda}{2}\left[\frac{\beta}{\beta-\alpha}\left(-\alpha i_t + \gamma_{j,t} - \frac{\alpha}{\beta}\eta_{j,t} + \varepsilon_t - \frac{\alpha}{\beta}\upsilon_t\right)\right]^2 \end{array}\right\} \tag{46}$$

Once developed, the above expression can be rewritten as:

$$\begin{array}{c} N_t = \frac{1}{2(\beta-\alpha)^2}\sum\limits_{j=1}^{n}\left(1+\lambda\beta^2\right)\alpha^2 i_t^2 \\ -\frac{2\alpha}{2(\beta-\alpha)^2}i_t\sum\limits_{j=1}^{n}\left[\gamma_{j,t} - \eta_{j,t} + \varepsilon_t - \upsilon_t + \lambda\beta^2\left(\gamma_{j,t} - \frac{\alpha}{\beta}\eta_{j,t} + \varepsilon_t - \frac{\alpha}{\beta}\upsilon_t\right)\right] \\ +\frac{1}{2(\beta-\alpha)^2}\sum\limits_{j=1}^{n}\left[\left(\gamma_{j,t} - \eta_{j,t} + \varepsilon_t - \upsilon_t\right)^2 - \lambda\beta^2\left(\gamma_{j,t} - \frac{\alpha}{\beta}\eta_{j,t} + \varepsilon_t - \frac{\alpha}{\beta}\upsilon_t\right)^2\right] \end{array} \tag{47}$$

which is equivalent to:

$$\begin{array}{c} N_t = n\frac{1+\lambda\beta^2}{2(\beta-\alpha)^2}\alpha^2 i_t^2 - \frac{\alpha}{(\beta-\alpha)^2}i_t\left(1+\lambda\beta^2\right)\sum\limits_{j=1}^{n}\gamma_{j,t} \\ +\frac{\alpha}{(\beta-\alpha)^2}i_t\left(1+\lambda\alpha\beta\right)\sum\limits_{j=1}^{n}\eta_{j,t} - \frac{\alpha}{(\beta-\alpha)^2}i_t\sum\limits_{j=1}^{n}\left[\left(1+\lambda\beta^2\right)\varepsilon_t - \left(1+\lambda\alpha\beta\right)\upsilon_t\right] \\ +\frac{1}{2(\beta-\alpha)^2}\sum\limits_{j=1}^{n}\left[\left(\gamma_{j,t} - \eta_{j,t} + \varepsilon_t - \upsilon_t\right)^2 - \lambda\beta^2\left(\gamma_{j,t} - \frac{\alpha}{\beta}\eta_{j,t} + \varepsilon_t - \frac{\alpha}{\beta}\upsilon_t\right)^2\right] \end{array} \tag{48}$$

Now, the second line of expression $(A4)$ is equal to zero because it is assumed that country-specific shocks cancel out at the aggregate level. The expression to be minimized therefore boils down to:

$$\begin{array}{c} N_t = n\frac{1+\lambda\beta^2}{2(\beta-\alpha)^2}\alpha^2 i_t^2 - \frac{\alpha}{(\beta-\alpha)^2}i_t\sum\limits_{j=1}^{n}\left[\left(1+\lambda\beta^2\right)\varepsilon_t - \left(1+\lambda\alpha\beta\right)\upsilon_t\right] \\ +\frac{1}{2(\beta-\alpha)^2}\sum\limits_{j=1}^{n}\left[\left(\gamma_{j,t} - \eta_{j,t} + \varepsilon_t - \upsilon_t\right)^2 - \lambda\beta^2\left(\gamma_{j,t} - \frac{\alpha}{\beta}\eta_{j,t} + \varepsilon_t - \frac{\alpha}{\beta}\upsilon_t\right)^2\right] \end{array} \tag{49}$$

The first order condition then straightforwardly leads to the following expression for the agreed upon interest rate:

$$i_t^N = \frac{1}{\alpha}\varepsilon_t - \frac{1+\lambda\alpha\beta}{\alpha(1+\lambda\alpha\beta^2)}\upsilon_t \tag{50}$$

Appendix 2.

Insert **Table 4** about here

Insert **Table 5** about here

Table 1.

Variance of the common interest rate, inflation, and output, and expected losses in a symmetric union

	n = 30			
	$var(i)$	$var(\pi)$	$var(y)$	$E(G)$
Nationalist hegemon (hegemon)	0.0135	0.184 E^{-5}	0.460 E^{-8}	0.924 E^{-6}
Nationalist hegemon (others)	/	0.387 E^{-5}	0.000886	0.000445
Bargaining, consensus	0.0067	0.272 E^{-5}	0.000404	0.000203
Majority voting	0.00686	0.276 E^{-5}	0.000413	0.000208
Primus inter pares (chairman)	0.00921	0.226 E^{-5}	0.000158	0.00008
Primus inter pares (others)	/	0.319 E^{-5}	0.000585	0.000294
Federalist chairman	0.00647	0.278 E^{-5}	0.000416	0.000209

$\alpha = 0.25$, $\lambda = 1$, $\beta = 20$, and $\sigma = 0.02$.

Estimates were computed from a series of 1000 draws of random shocks.

Table 2.

Variance of the common interest rate in an asymmetric union

	Var(i)
Dutch chairman	0.0032
Bargaining	0.00423
Federal chairman	0.00507
Federal hegemony	0.00527
Majority voting	0.00638
Consensus	0.00865
French chairman	0.0114
German hegemony	0.0196

$\lambda = 1$, $\beta = 20$, and $\sigma = 0.02$.
$\alpha_{aus} = 0.25$; $\alpha_{bel} = 0.32$; $\alpha_{esp} = 0.14$;
$\alpha_{fin} = 0.44$; $\alpha_{fra} = 0.20$; $\alpha_{ger} = 0.20$;
$\alpha_{irl} = 0.32$; $\alpha_{ita} = 0.12$; $\alpha_{nld} = 0.45$.
Estimates were computed from a series of 1000 draws of random shocks.

Table 3.

Expected losses

	German hegemony	Federal hegemon	Bargaining	Consensus	Majority	Dutch Chairman	French chairman	Federal chairman
Austria	*0.000542*	0.000205	0.000196	0.000201	**0.000195**	0.000259	0.000298	0.000201
Belgium	*0.000824*	0.000215	**0.000183**	0.000261	0.000208	0.000271	0.000381	0.000208
Spain	*0.000303*	0.000245	0.000257	**0.000194**	0.000231	0.000298	0.000244	0.000245
Finland	*0.0015*	0.000298	**0.000184**	0.000468	0.000328	0.000297	0.000732	0.000284
France	*0.000430*	0.000221	0.000227	**0.000187**	0.000204	0.000282	<u>0.0000971</u>	0.00022
Germany	<u>0.103.E^{-5}</u>	0.000222	0.000224	**0.000181**	0.000205	0.000289	0.000267	0.000220
Ireland	*0.000745*	0.000192	**0.000164**	0.00022	0.000186	0.000262	0.000374	0.000188
Italy	0.000301	0.000263	0.000276	**0.000208**	0.000250	*0.000310*	0.000258	0.000263
Netherlands	*0.00164*	0.000304	**0.00018**	0.00048	0.000344	<u>0.0000490</u>	0.000754	0.000287

$\lambda = 1$, $\beta = 20$, and $\sigma = 0.02$. $\alpha_{aus} = 0.25$; $\alpha_{bel} = 0.32$; $\alpha_{esp} = 0.14$; $\alpha_{fin} = 0.44$; $\alpha_{fra} = 0.20$; $\alpha_{ger} = 0.20$; $\alpha_{irl} = 0.32$; $\alpha_{ita} = 0.12$; $\alpha_{nld} = 0.45$.
Estimates were computed from a series of 1000 draws of random shocks. Numbers in bold (italic) indicate each country's minimum (maximum) losses. When a country is either the hegemon or chairs the union, its lowest losses are underlined and its second lowest losses are in bold.

Table 4.

Variance of inflation

	German hegemony	Federal hegemon	Bargaining	Consensus	Majority	Dutch Chairman	French chairman	Federal chairman
Austria	*0.491.E^{-5}*	0.309.E^{-5}	0.309.E^{-5}	**0.303.E^{-5}**	0.304.E^{-5}	0.349.E^{-5}	0.339.E^{-5}	0.307.E^{-5}
Belgium	*0.610.E^{-5}*	0.301.E^{-5}	**0.286.E^{-5}**	0.316.E^{-5}	0.296.E^{-5}	0.34.E^{-5}	0.363.E^{-5}	0.298.E^{-5}
Spain	*0.349.E^{-5}*	0.319.E^{-5}	0.324.E^{-5}	**0.293.E^{-5}**	0.311.E^{-5}	0.346.E^{-5}	0.311.E^{-5}	0.318.E^{-5}
Finland	*0.959.E^{-5}*	0.348.E^{-5}	**0.296.E^{-5}**	0.44.E^{-5}	0.37.E^{-5}	0.363.E^{-5}	0.556.E^{-5}	0.341.E^{-5}
France	*0.439.E^{-5}*	0.332.E^{-5}	0.339.E^{-5}	**0.316.E^{-5}**	0.325.E^{-5}	0.373.E^{-5}	<u>0.296.E^{-5}</u>	0.332.E^{-5}
Germany	<u>0.205.E^{-5}</u>	0.297.E^{-5}	0.299.E^{-5}	**0.278.E^{-5}**	0.290.E^{-5}	*0.332.E^{-5}*	0.314.E^{-5}	0.297.E^{-5}
Ireland	*0.556.E^{-5}*	0.281.E^{-5}	**0.262.E^{-5}**	0.282.E^{-5}	0.268.E^{-5}	0.314.E^{-5}	0.353.E^{-5}	0.277.E^{-5}
Italy	0.358.E^{-5}	0.339.E^{-5}	0.346.E^{-5}	**0.310.E^{-5}**	0.332.E^{-5}	*0.367.E^{-5}*	0.327.E^{-5}	0.340.E^{-5}
Netherlands	*0.101.E^{-4}*	0.327.E^{-5}	**0.267.E^{-5}**	0.41.E^{-5}	0.344.E^{-5}	<u>0.207.E^{-5}</u>	0.526.E^{-5}	0.318.E^{-5}

$\lambda = 1$, $\beta = 20$, and $\sigma = 0.02$. $\alpha_{aus} = 0.25$; $\alpha_{bel} = 0.32$; $\alpha_{esp} = 0.14$; $\alpha_{fin} = 0.44$; $\alpha_{fra} = 0.20$; $\alpha_{ger} = 0.20$; $\alpha_{irl} = 0.32$; $\alpha_{ita} = 0.12$; $\alpha_{nld} = 0.45$.

Estimates were computed from a series of 1000 draws of random shocks. Numbers in bold (italic) indicate each country's minimum (maximum) volatility. When a country is the hegemon or chairs the committee, its lowest volatility is underlined and its second lowest volatility is in bold.

Table 5.

Variance of output

	German hegemony	Federal hegemon	Bargaining	Consensus	Majority	Dutch Chairman	French chairman	Federal chairman
Austria	*0.00108*	0.000406	0.000387	0.000397	**0.000385**	0.000513	0.000591	0.000397
Belgium	*0.00164*	0.000428	**0.000362**	0.000519	0.000413	0.00054	0.000758	0.000413
Spain	*0.000603*	0.000487	0.000510	**0.000385**	0.000458	0.000592	0.000484	0.000486
Finland	*0.00299*	0.000590	**0.000362**	0.000927	0.00065	0.000588	0.00146	0.000563
France	*0.000855*	0.000438	0.00045	**0.000371**	0.000405	0.00056	<u>0.000191</u>	0.000436
Germany	<u>$0.512.E^{-8}$</u>	0.000441	0.000444	**0.000358**	0.000406	0.000575	0.000530	0.000437
Ireland	*0.00148*	0.00038	**0.000325**	0.000435	0.00037	0.00052	0.000744	0.000374
Italy	0.000597	0.000521	0.000548	**0.000413**	0.000496	*0.000616*	0.000511	0.000522
Netherlands	*0.00327*	0.000604	0.000357	**0.000955**	0.000685	<u>0.0000957</u>	0.00150	0.000571

$\lambda = 1$, $\beta = 20$, and $\sigma = 0.02$. $\alpha_{aus} = 0.25$; $\alpha_{bel} = 0.32$; $\alpha_{esp} = 0.14$; $\alpha_{fin} = 0.44$; $\alpha_{fra} = 0.20$; $\alpha_{ger} = 0.20$; $\alpha_{irl} = 0.32$; $\alpha_{ita} = 0.12$; $\alpha_{nld} = 0.45$. Estimates were computed from a series of 1000 draws of random shocks. Numbers in bold (italic) indicate each country's minimum (maximum) volatility. When a country is the hegemon or chairs the committee, its lowest volatility is underlined and its second lowest volatility is in bold.