Should the Individual Voting Records of Central Bankers be Published?*

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Abstract

We examine whether the publication of the individual voting records of central-bank council members is socially beneficial when the public is unsure about the efficiency of central bankers and central bankers are angling for re-appointment. We show that publication is initially harmful since it creates a conflict between socially desirable and individually optimal behavior for somewhat less efficient central bankers. However, after re-appointment, losses will be lower when voting records are published since the government can distinguish highly efficient from less efficient central bankers more easily and can make central bankers individually accountable. In our model, the negative effects of voting transparency dominate, and expected overall losses are always larger when voting records are published.

Keywords: Central Banks, Transparency, Voting.

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1 Introduction

The question of transparency in connection with central banks, and for the Federal Reserve and the European Central Bank (ECB) in particular, has triggered a lively discussion among academics and policy-makers. How transparent should they be? And what does transparency actually mean in this context?

Whether the publication of voting records is socially beneficial is one of the most controversial issues. The publication of voting records is advocated by Buiter (1999), among others. In general, he argues that individual accountability produces better results than collective responsibility. Under individual accountability, members who find themselves in the minority would be able to publicly argue their case for a different monetary policy. Additionally, individual members' competence can only be assessed with a track record of individual votes. This is important for re-appointments and for departing members' prospects of employment in other responsible positions. On the other hand, Issing (1999), among others, has expressed concern about the pressure that national authorities would exert on the members of the ECB council if individual voting behavior were published. This argument is also developed in a formal model by Gersbach and Hahn (2003).

Our paper also contributes to an emerging theoretical literature on the optimal design of independent central bank boards with several members appointed by the government. Waller and Walsh (1996) provide a comprehensive account of how central bank independence can be characterized in terms of competitiveness, partisanship, and term length. Waller (2000) shows that a group of politically appointed central bankers can produce substantial policy smoothing and low policy uncertainty. Our paper is complementary to this literature as we focus on whether the votes of individual central bankers for a given design of the board should be made transparent to the political authorities that appoint central bankers.

We build a simple model of collective decision-making among central bankers who are motivated by holding office and thus by their reputation as competent central bankers. In this respect, our model belongs to the literature on career concerns, which were first modelled formally by Holmström (1982). In a technical sense, our paper deals with agents who have private information about an unknown state of the world and are concerned about their career. The literature developed by Scharfstein and Stein (1995), Trueman (1994), and Ottaviani and Sørensen (2001) is concerned with herding problems when experts suppress their private information in order to appear well-informed. Ottaviani and Sørensen (2001), in particular, develop a theory about which experts should speak first in order to achieve optimal information aggregation in debates. We complement this literature by considering how reputation-building is affected by the transparency regime. Visser and Swank (2005) develop an interesting model where experts derive utility from being perceived as competent and from policy outcomes. Their focus, however, is not on transparency. Prat (2005) examines transparency for a career concern model with one individual expert.[1]

To our knowledge, there exist only a few theoretical papers dealing with the publication of voting records and the minutes of central-bank council meetings.[2] In a recent contribution, Levy (2005) examines transparency and different voting rules for a committee of three experts. She finds that transparency may induce group members to comply with pre-existing biases.[3] Sibert (2003) presents an interesting model of reputation-building in monetary policy committees. She examines the incentives for individual central bankers to build a reputation for being tough on inflation when they are part of a committee. She argues that transparency might improve reputation-building. In our paper, we compare the relative merits of individual and collective reputation-building when reputation has to do with the competence of central bankers. Under transparency, re-appointment decisions depend on the individual reputation for being competent, while under opacity re-appointment is contingent on collective reputation only.

Gersbach and Hahn (2004) show that the publication of voting records may be beneficial if central bankers pursue different objectives. Their result, however, is reversed for a monetary union where central bankers may pursue the interests of their national countries (see Gersbach and Hahn (2003)). In this case transparency may lead to increased national outsider pressure and induce central bankers to behave in the interests of their own governments. This may be detrimental for the monetary union.

In our paper, we identify the costs and benefits of voting transparency in a simple model in which central bankers differ in their efficiency in identifying which monetary policy decision would lead to socially optimal outcomes. Of course, one might argue that all central bank council members are provided with the same data by their staff, so differences in knowledge would be irrelevant. Nevertheless, monetary policy is sometimes “as much art as science,” as the former vice-president of the Fed, Alan Blinder,

[1]Fingleton and Raith (2005) show that a principal may prefer agents to bargain behind closed doors, which prevents them from bargaining very aggressively.

[2]A survey of the literature on central-bank transparency can be found in Geraats (2002), Hahn (2002), and in the general assessment of central-bank transparency by Blinder et al. (2001). Fujiki (2005) presents an interesting overview of the literature on monetary policy committees.

[3]Her model differs from ours in at least two respects. First, she does not consider re-appointment explicitly, so the beneficial effect of transparency identified in our paper does not occur. Second, all members are specialized, i.e., they receive signals about uncorrelated random variables.

put it.[4] Therefore it is not implausible to assume that some central bankers are more proficient than others in the art of judging which interest rates are adequate.

While a completely accurate formal description of the discussion among council members, the exchange of views before formal voting takes place, and the voting process is certainly not feasible, we attempt to capture the basic features of actual decision-making by introducing a two-stage decision process. Central bankers may either choose to play an active role in the discussion and in decision-making, or they may wait and listen to other members' views before making a decision. We believe that this two-stage procedure, although definitely a simplification, captures the essential features of the dynamic process of exchanging views in a monetary policy committee.[5] It is important to note that the two-stage procedure applied in this paper is able to deliver an efficient aggregation of information. Less efficient members can wait and listen to the arguments of their more efficient colleagues, which enables them to make the best choices possible. In addition, highly efficient central bankers can not do better by announcing their views sequentially, as the simultaneous divulgence of their private information already amounts to an efficient aggregation of information.

It is worth noting that in our model the discussion among central bankers and the voting procedure are not modelled separately. But this may be deemed a desirable feature since, e.g. in the ECB council, decisions are usually not reached by formal voting. Thus, voting transparency in our model cannot be separated from the publication of the minutes of the meetings.

We show that transparency yields higher losses in the first period and lower losses in the second. The intuition runs as follows: The benefits of transparency arise from the way it enables the government to more easily distinguish the highly efficient from the somewhat less efficient central bankers. The government can thus improve the overall competence of the central-bank council over time by re-appointing only manifestly highly efficient central bankers. But there is a serious disadvantage to transparency. To avoid being dismissed, less efficient central bankers will try to give the impression of expertise whenever their individual behavior can be observed. Transparency induces them to play a more active role in decision-making. But since they do not know whether interest rates should be raised or lowered, the probability of error on their part is rather high. The likelihood that the central bank will adopt the appropriate interest-rate policy decreases and social losses are higher than they would be in the absence of transparency, since transparency enables less efficient central bankers to behave

[4]See Blinder (1997), p. 17.

[5]In a note, Hahn (2001) shows that our results also hold for a voting procedure involving more stages.

more passively and to listen to the arguments of their more proficient colleagues. We show that these costs exceed the benefits of transparency gained by assembling a highly efficient central-bank council. Hence, overall social losses are larger under transparency.

We focus on the majority rule, as all major central banks like the Fed, the Bank of Japan or the Bank of England use majority voting. The "Treaty on European Union" also stipulates majority voting for the ECB Governing Council. A further interesting research issue for general committee settings is the impact of transparency when decisions are taken unanimously (see e.g. Feddersen and Pesendorfer (1998) or Levy (2005)).

The paper is organized as follows: In the next section we describe the model. We introduce assumptions about the re-appointment schemes in section 3. In the subsequent two sections, the results for the first and the second period are derived. Then we attempt an overall comparison between transparency and opacity in section 6. Section 7 presents our major conclusions.

2 Model

In Gersbach and Hahn (2004) we show that a simple aggregate demand/aggregate supply framework with supply shocks can be used to derive the following instantaneous social loss function in period t ($t = 1, 2$):

$$L_t = \begin{cases} 0 & \text{if } I_t = I_t^* \\ 1 & \text{if } I_t \neq I_t^* \end{cases}$$

where I_t is the instrument chosen by the central bank committee and I_t^* is the optimal choice of the instrument. Henceforth we will use the term "interest rate" for the instrument. We normalize the two possible realizations of I_t^* to $+1$ and -1, respectively. This simplifies the analysis but is not crucial to our results. In a similar vein, we have also normalized social losses to 1 if a wrong decision is taken and to 0 if the interest rate is correct.

A crucial issue is the utility gained by central bankers when in office. There are two possible motives. Central bankers can be motivated by certain policies, i.e. they would like to minimize their individual loss function depending only on inflation and output.[6] Or they may derive additional private benefits from being a central banker, i.e. from the prestige and satisfaction of work on the council. Both approaches to the formulation of utilities for central bankers are equally plausible and give rise to transparency issues.

[6]The case where central bankers want to minimize the social loss function is a special case.

In this paper, we follow the latter approach; each central banker is assumed to derive large private benefits from being on the council. The observation that Alan Greenspan agreed to a fifth term of office in 2004, although he was almost 78 at the time, may indicate that private benefits are high.[7] Another anecdotal evidence is the episode in the "Economist", Aug 4th 2005, "Fazio's future". The then president of the Bank of Italy was reported to "like his job as boss of the Bank of Italy." He obstinately resisted mounting pressure to resign as a consequence of his dubious role in a takeover battle. The fact that top central bankers like their jobs has been confirmed to us also in private communication with major central bankers.

A central banker's losses in period t are given by

$$L_t^{CB} = L_t - B_t \tag{1}$$

B_t denotes private benefits emanating from being a member of the central-bank council. These benefits are zero if not a member and large otherwise.

$$B_t = \begin{cases} \overline{B} & \text{if in office} \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

For simplicity, these private benefits are assumed to be so large that a central banker has lexicographical preferences and will maximize his probability of re-appointment. Only if the probability of re-appointment does not depend on his action, will he choose the action that minimizes social losses. However, the equilibrium identified in our paper also exists if we make the weaker assumption $\overline{B} \geq 1$.

It is obvious that transparency can only have a differential impact if there is some heterogeneity among central bankers. There are two possible ways for differences among central bankers to emerge. First, central bankers may have different preferences, e.g., put different emphasis on output stabilization. Second, central bankers may have different degrees of knowledge concerning the way the economy works.[8]

In this paper, we will explore the second avenue and distinguish between highly efficient and less efficient central bankers.[9] A highly efficient central banker will make more accurate judgments about the magnitude of shocks in the economy. We assume that the judgment of a highly efficient central banker will be correct with probability p ($1/2 < p \leq 1$), and incorrect with probability $1 - p$. The probability of a correct judgment is

[7] However, this observation could also be explained by the fact that Alan Greenspan knew that his competence exceeded a likely successor's competence. Thus it is also conceivable that he remained in office due to welfare considerations.

[8] The heterogeneity could also be caused by otherwise identical central bankers belonging to different generations. A model of overlapping generations of central bankers is examined in Sibert (2003).

[9] An analysis of the first case is conducted in Gersbach and Hahn (2004).

the same for all highly efficient central bankers, and its size is commonly known. Less efficient central bankers are less able to judge the future course of the economy, and we assume that the probability of their predicting shocks correctly amounts to 1/2. In other words, a less efficient central banker does not have any informative indications about the magnitude of shocks. This is obviously an extreme assumption, but it helps to keep the analysis simple and is not crucial for our results. We assume that central bankers know their own ability.[10]

We consider a two-period model, with the periods denoted by $t = 1$ and $t = 2$. Overall social losses are given by

$$L = L_1 + \delta L_2 \tag{3}$$

δ $(0 < \delta < 1)$ denotes the discount factor. The subscripts denote the period.

Accordingly, a central banker's losses amount to

$$L^{CB} = (L_1 - B_1) + \delta(L_2 - B_2) \tag{4}$$

Monetary policy is in the hands of the council of the central bank, which decides by majority rule which short-term interest rate will be set. The sequence of events is as follows:

- **1st Period**
  - At the beginning of the first period, the council is formed, comprising N central bankers ($N \geq 1$, N odd). There is equal probability of any member being highly efficient or less so. The efficiency of each member is private information.
  - Highly efficient central bankers observe a signal indicating the magnitude of the shock. The probability of a highly efficient central banker's judgment being correct is p.
  - Members decide whether to play an active role or a passive role in decision-making.
  - All members who have chosen to play an active role vote for their preferred interest rate i simultaneously. For simplicity of exposition, we assume that only two choices are possible, which correspond to the two possible realizations of I_t^*.[11]

[10] The issue of whether agents know their own ability has been debated in the literature on career concerns by experts. Since central bankers are senior experts, it is plausible to assume that central bankers know their type.

[11] It is obvious that more interest rates are possible in reality. We implicitly assume here that each

- All remaining members are informed about the decisions of their more active colleagues and vote afterwards.
- The interest rate preferred by the majority is set by the central bank.
- The shock materializes and is observed by the central bankers and the government.
- The complete history of the decision-making process is either published under a transparency requirement or remains secret for all outsiders under opacity.

• **2nd Period**

- At the beginning of the second period, the (re-)appointment of the members of the central-bank council takes place. The government can dismiss any central banker and replace him by another central banker from a pool of candidates. The probability of newly appointed central bankers being highly efficient is 1/2.
- The rest of the second period is identical to the first period.

This model of decision-making imposes the restriction that active central bankers cannot change their views, i.e. they cannot vote differently after having observed the votes of the other active members. Under opacity, we will see that, in equilibrium, a highly efficient central banker will believe that he chose the wrong interest rate when he observes that a majority of votes is in favor of the other interest rate. However, allowing the active central bankers to change their votes in this case would not affect the outcome of votes and hence social losses, since they would simply vote for the interest rate that would be adopted anyhow.

Moreover, one has to keep in mind that one council meeting in our model corresponds to a whole term in office and should be interpreted as a representative meeting. Changing one's mind may be acceptable occasionally, but someone who changes his mind very often would probably arouse concern about his competence and thus may not be reappointed. Such considerations should prevent central bankers from changing their opinion frequently, in particular under transparency. Under transparency, changing one's vote may not even be beneficial for active central bankers in equilibrium, as the government will evaluate the competency of central bankers on the basis of their first votes.

In the following, we describe a behavior that leads to maximal probability of the correct interest rate being chosen. Let OPT be the following behavior of central bankers:

time a decision has to be taken only two candidate interest rates are potentially appropriate, e.g., leaving the interest rate unchanged or lowering it by 25 basis points.

Each highly efficient central banker plays an active role and chooses the interest rate supported by his signal. Less efficient central bankers play a passive role and vote in accordance with the majority of their more active colleagues. If the highly efficient central bankers reach a draw, the less efficient central bankers randomize[12] between the two possible interest-rate decisions with equal probability. OPT has the following feature:

Proposition 1
If all central bankers vote according to OPT, then the council achieves the highest possible probability for a correct interest rate.

Proof
Consider a social planner who wants to choose the interest rate that has the highest probability of being correct. The social planner would choose the interest rate that a majority of informative signals indicates to be correct. He would be indifferent if there were a split between the number of informative signals supporting one or the other interest rate. Therefore OPT realizes a socially optimal interest-rate decision.[13]

□

3 Assumptions About Re-appointment Schemes

In this section, we assume some plausible features of the government's re-appointment procedure. Later we will see that equilibria exist that satisfy these assumptions.

Under transparency, we assume that the government dismisses each central banker who has played a passive role with higher probability than a central banker who has voted for the same interest rate but played an active role. The intuition for this is that less efficient central bankers, who do not obtain a private signal, may try to listen to the colleagues who play an active role.[14] Thus a passive role in decision-making may be an indication of a lower level of competence. Moreover, we assume that the government never re-appoints an active central banker with higher probability when he has voted for the wrong interest rate compared to the correct interest rate.

[12] While it may seem unrealistic for central bankers to make random decisions by, e.g., casting dice, randomizing in our model should simply be interpreted as decisions that are not based on knowledge or judgment and are thus unpredictable.

[13] We note that OPT is not the only voting behavior that maximizes the probability of a correct outcome. We will take up this issue again in section 4.1.

[14] Note that we could also make the opposite assumption that all central bankers who play a passive role are dismissed with lower probability. This would lead to an equilibrium where all central bankers always play a passive role. However, our findings with respect to welfare would remain valid.

Let us introduce the probability of re-appointment for a central banker who has played an active role (A) or a passive role (P) and has voted for the correct interest rate. This probability is denoted by $\mu^T_{I,C,X}$ ($X \in \{A, P\}$) under transparency if the correct interest rate is I. Similarly, $\mu^T_{I,W,X}$ is the probability of re-appointment if I is correct but the central banker has voted for the wrong interest rate.

Now we can formally state our assumptions about the re-appointment scheme under transparency (henceforth AT) as follows:

$$\mu^T_{I,C,A} > \mu^T_{I,C,P} \quad \text{and} \quad \mu^T_{I,W,A} \geq \mu^T_{I,W,P} \qquad \forall I \in \{-1, +1\} \tag{5}$$

$$\mu^T_{I,C,A} \geq \mu^T_{I,W,A} \qquad \forall I \in \{-1, +1\} \tag{6}$$

Note that we do not exclude the possibility of different re-appointment probabilities for different central bankers, although we do not explicitly introduce an index for individual central bankers.[15]

In the absence of transparency, the government will either fire the whole council or leave them in office, since the government does not know how each single central banker contributed to the decision. We assume that the probability of re-appointment is weakly higher for a council that has identified the correct interest rate rather than the wrong interest rate.

Formally, this can be stated as

$$\mu^O_{I,C} \geq \mu^O_{I,W} \qquad \forall I \in \{-1, +1\} \tag{7}$$

where $\mu^O_{I,X}$ ($X \in \{C, W\}$) is the probability of the council being re-appointed if I is correct and the council has voted for the correct interest rate (C) or wrong interest rate (W) respectively. In the following we will refer to this assumption as AO.

A perfect Bayesian Nash equilibrium consists of monetary policy votes in the first and second period and the re-appointment scheme. Since first-period equilibrium monetary-policy votes are independent of second-period votes, we can examine the first period before analyzing the second.

[15]Note that we could also make the weaker assumption $\mu^T_{I,C,A} \geq \mu^T_{I,C,P}$ $\forall I \in \{-1, +1\}$. However, it seems implausible that $\mu^T_{I,C,A} = \mu^T_{I,C,P}$, because a central banker who has voted correctly seems to be more likely to be competent when he has played an active role and thus has gained no information about the signals of his colleagues, compared to the situation where he has behaved passively. If we allowed for $\mu^T_{I,C,A} = \mu^T_{I,C,P}$, the equilibrium would only be unique if we used a coordination argument as under opacity in the first period.

4 The First Period

4.1 Opacity

Under opacity, the voting behavior in the first period is not unique, which is a typical phenomenon in voting games. For example, if all central bankers always vote for $+1$, no central banker has an incentive to deviate, even if he is highly efficient, his signal is very accurate ($p = 1$), and it indicates that -1 is correct. The reason is that he cannot influence the voting outcome. In a similar vein, the voting behavior is not unique in the second period both under opacity and under transparency.

Hence we consider only perfect Bayesian Nash equilibria of the overall game where no profitable joint deviation exists for all central bankers at each voting stage, given the government's re-appointment scheme. Thus we assume that central bankers can coordinate on a behavior that, given a government's re-appointment scheme satisfying AO, guarantees the maximum likelihood of re-appointment. For a constant probability of re-appointment, central bankers maximize the probability of a beneficial outcome in the first period. Note that there is no conflict of interest between the council members, i.e., all central bankers want to achieve high probability of re-appointment and high probability of a beneficial outcome. Thus, under opacity in particular, where central bankers can talk in private, it seems plausible that central bankers can avoid voting behavior that is harmful to every one of them.

Our assumption is related to the concepts of coalition-proofness and strong Nash equilibrium (see Bernheim et al. (1987) and Aumann (1959)). However, we only consider joint deviations of all central bankers as opposed to deviations of arbitrary groups of players.[16] The same concept has been applied by Genicot and Ray (2006) who consider a principal-agent model where the agents are allowed to coordinate on joint deviations.

Following Proposition 1, all central bankers may choose behavior OPT if the government applies a re-appointment scheme that satisfies AO. We summarize this observation in the following proposition:

Proposition 2
Consider opacity in the first period and a re-appointment scheme that satisfies assumption AO. Then behavior OPT maximizes the probability of the council being re-appointed. Moreover, if the probability of re-appointment does not depend on the behavior of central bankers ($\mu^O_{I,C} = \mu^O_{I,W}\ \forall I \in \{-1, +1\}$), central bankers maximize

[16] Because the interests of all central bankers are aligned, no subset of central bankers can profitably deviate if the joint group of all central bankers cannot.

the likelihood of beneficial monetary policy by choosing OPT. No individual central banker has an incentive to deviate if all central bankers follow OPT.

We note that the behavior that maximizes the likelihood of beneficial policy outcome is not unique. However, the alternative behaviors that maximize the likelihood of the correct interest rate being chosen differ from OPT only in the probabilities of the less efficient central bankers choosing -1 and $+1$ in the case of a draw among the highly efficient colleagues. Our assumption that OPT is chosen obviously does not affect our findings about welfare in the first period. It also does not affect our findings about welfare in the second period, because it can be shown that these alternative behaviors would either lead to the same re-appointment procedure as the one in the equilibrium we consider or would lead to a contradiction because the optimal re-appointment scheme would violate assumption (7). In a similar vein, the behavior of central bankers in the second period will not be unique, even if central bankers are able to coordinate on a behavior that maximizes welfare. However, all behaviors lead to identical social losses. Consequently we assume in the following that the coordination of central bankers always leads to OPT.

All that remains is to derive the government's re-appointment scheme.

Proposition 3
If all central bankers choose OPT in the first period under opacity, then the optimal re-appointment scheme is given by

$$\mu^O_{+1,C} = \mu^O_{-1,C} = 1 \tag{8}$$
$$\mu^O_{+1,W} = \mu^O_{-1,W} = 0 \tag{9}$$

Proposition 3 follows directly from the observation that the probability of a council choosing the correct interest rate in the second period is strictly higher for a council that has chosen the correct interest rate in the first period as opposed to a newly appointed council. Thus the government strictly prefers to re-appoint any central bank council that has chosen the correct interest rate. For similar reasons, the government strictly prefers to dismiss a council that has chosen the wrong interest rate in the first period.

We next derive equilibrium social losses under opacity. In the following, we use n to denote the number of highly efficient members. Recall that at first n is known neither to the central bankers nor to the government. According to Proposition 2 the less efficient central bankers simply follow the majority. Consequently, they will not affect the outcome of the decision-making process. Hence, the probability of the majority of central bankers estimating the direction of the shock correctly is equal to the probability that the estimate of at least $(n+1)/2$ efficient central bankers is correct, which is given by

$$P(n) = \begin{cases} \sum_{i=(n+1)/2}^{n} \binom{n}{i} p^i (1-p)^{n-i} & \text{if } n \text{ odd} \\ \sum_{i=n/2+1}^{n} \binom{n}{i} p^i (1-p)^{n-i} + \frac{1}{2}\binom{n}{n/2} p^{n/2}(1-p)^{n/2} & \text{if } n \text{ even} \end{cases} \tag{10}$$

The last term of $P(n)$ for an even value of n gives the probability of a correct direction of the interest rate in the case of a draw. There will be randomization between the two choices, reflected by the factor 1/2.

We note that $P(n)$ is weakly increasing in n for the following reasons. It is straightforward to show that $P(n+1) = P(n)$ if n is odd. Intuitively, an increase in the number of highly efficient central bankers by one when n is odd produces more ties and more correct judgments of the interest-rate policy by the majority. The two effects cancel each other out. Moreover, the fact that $P(n+1) > P(n)$ for an even number of n follows from the Condorcet Jury Theorem, which goes back to Condorcet (1785).[17]

It is useful to define

$$\overline{P} = \frac{1}{2^N} \sum_{n=0}^{N} \binom{N}{n} P(n) \tag{11}$$

which is the probability that an outside observer assigns to the eventuality of the majority of central bankers voting correctly.

With the use of $\overline{P}$, expected losses in the first period, denoted by L_1^O, are given by

$$L_1^O = 1 - \overline{P}$$

L_1^O depends negatively on p since, if p increases, the probability that the council vote is correct will also increase.

4.2 Transparency

With respect to the highly efficient central bankers' behavior, their equilibrium behavior under transparency will be quite similar to the equilibrium developed in the previous section. But less efficient central bankers will not play a passive role in decision-making. The government would observe who does not actively participate in the decision-making process and would dismiss the respective members to improve the pool of highly efficient central bankers. Therefore less efficient central bankers will be active and as they are unwilling to listen to the statements of their more proficient colleagues they will randomize between the two possible interest rates in order to have a fifty percent chance

[17] For a formal presentation, see, e.g., Boland (1989).

of not being detected as less efficient. Compared to the case without transparency, this effect will increase social losses in the first period since the probability that the outcome is optimal will decrease.

The following proposition holds:

Proposition 4
Under transparency, assume that the government's re-appointment scheme squares with assumptions AT. Then each highly efficient central banker will play an active role and will opt for the interest rate suggested by his private signal. Less efficient central bankers will always play an active role.

Proof
It is straightforward to verify that assumption (5) implies that no central banker will choose a passive role, because this would imply strictly lower probability of re-appointment.

Consider a highly efficient central banker who has observed signal $s \in \{-1, +1\}$. If the central banker chooses s, the probability of re-appointment is higher than for choosing $-s$ if

$$p\mu^T_{+s,C,A} + (1-p)\mu^T_{-s,W,A} > (1-p)\mu^T_{-s,C,A} + p\mu^T_{+s,W,A} \tag{12}$$

Because of assumptions AT, this inequality always holds. If this inequality holds with equality, then highly efficient central bankers will nevertheless prefer s, as this would maximize the probability of a beneficial outcome in the first period. Thus highly efficient central bankers always follow their signals.

□

Now assume that every less efficient central banker i chooses $+1$ with some probability σ_i and -1 with probability $1-\sigma_i$. In the following proposition we determine the values for σ_i:

Proposition 5
The only values for σ_i that are compatible with assumptions AT are $\sigma_i = \frac{1}{2}\ \forall i \in \{1..N\}$.

The proof is given in the appendix. The following proposition determines the government's optimal re-appointment scheme:

Proposition 6
Suppose that AT holds. Then any re-appointment scheme under transparency has the following properties:

$$\mu^T_{-1,C,A} = \mu^T_{+1,C,A} = 1 \tag{13}$$

$$\mu^T_{-1,W,A} = \mu^T_{+1,W,A} = 0 \tag{14}$$

Hence a central banker is re-appointed if and only if he has chosen the correct interest rate. The proof is given in the appendix.

In order to derive expected losses, we will first define the probability, denoted by Q, that if each member has a 50% chance of being highly efficient the majority will choose the correct interest rate.

We can write Q in a convenient way:

$$Q = \sum_{i=(N+1)/2}^{N} \binom{N}{i} \left(\frac{1}{2}\left(p+\frac{1}{2}\right)\right)^{i} \left(1-\frac{1}{2}\left(p+\frac{1}{2}\right)\right)^{N-i} \tag{15}$$

where we take account of the fact that each central banker casts a correct vote with probability $\frac{1}{2}\left(p+\frac{1}{2}\right)$, because the probability of an individual central banker being highly efficient and casting a correct vote amounts to $\frac{1}{2}\cdot p$ and the probability of a central banker being less efficient and casting a correct vote amounts to $\frac{1}{2}\cdot\frac{1}{2}$. With this definition we immediately obtain expected losses in the first period as

$$L_1^T = 1 - Q \tag{16}$$

4.3 Comparison

We compare first-period losses with the following proposition:

Proposition 7
Losses in the first period are always larger under transparency than under opacity.

The proof is straightforward from the observation that behavior in the first period under transparency does not implement the optimal solution, which is detailed in the proof of Proposition 1.

This result is quite plausible. Under transparency, no less efficient central banker will dare to play a more passive role to find out the opinions of his more able colleagues since he would not be re-appointed if he did. This will induce less efficient central bankers to play an active role and randomize between the two possible positions. The probability of a correct decision being reached will decrease accordingly.

5 The Second Period

5.1 Opacity

In the second period multiple equilibria also exist. However, as in the first period, we assume that central bankers coordinate on behavior that guarantees the maximal probability of a beneficial outcome. We summarize this observation by the following proposition:

Proposition 8
Under opacity, the following perfect Bayesian Nash equilibrium exists in the voting game of the second period. All central bankers follow OPT.

To derive expected losses, we need to compute the likelihood of n central bankers being competent in the second period. This probability is given by

$$\rho^O(n) = \frac{1}{2^N}\binom{N}{n}P(n) + (1-\overline{P})\frac{1}{2^N}\binom{N}{n} \tag{17}$$

Note that the first term is the probability that there are n highly efficient members on the original council and that they are not replaced because they chose the right monetary policy. The second term corresponds to the probability of the original council being dismissed and the newly formed council having n highly efficient central bankers.

Expected losses under opacity in the second period can now be written as

$$L_2^O = \sum_{n=0}^{N} \rho^O(n)\big(1-P(n)\big) \tag{18}$$

5.2 Transparency

Again we assume that central bankers coordinate on the behavior that guarantees the maximal probability of a correct interest-rate decision. Thus, we obtain

Proposition 9
In the second period, under transparency, the following perfect Bayesian Nash equilibrium of the voting game exists. All central bankers follow OPT.

Then in the second period, the equilibrium losses under transparency will be the same as under opacity for a given number of highly efficient central bankers. Less efficient central bankers will play a passive role and follow their more active colleagues because they will gain no benefit from making the government believe that they are highly efficient but would exacerbate social losses if they voted in the first stage of the decision-making process. However, the probability that n central bankers will be highly efficient in the second period is different under transparency, thus changing expected losses over and against opacity. In the second period, expected losses will be smaller under transparency since the average number of highly efficient central bankers will be larger. This is due to the fact that the government is better able to distinguish highly efficient from less efficient central bankers when each central banker can be made accountable for his policy preferences.

If we define $\rho_N^T(n)$ as the probability of n highly efficient central bankers being present in the second period, expected losses can be written as[18]

$$L_2^T = \sum_{n=0}^{N} \rho_N^T(n)\big(1 - P(n)\big) \tag{19}$$

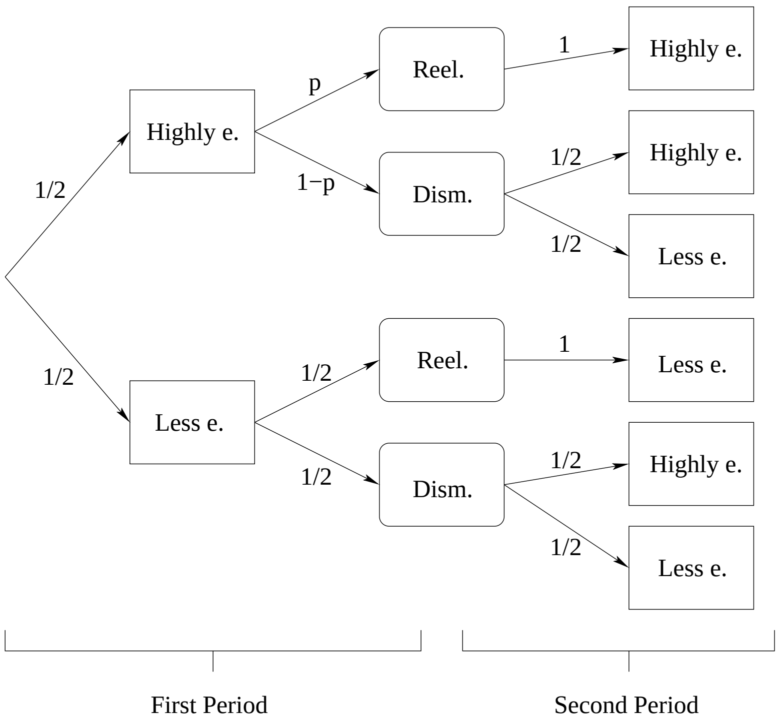

Figure 1: The calculation of $\rho_1^T(0)$ and $\rho_1^T(1)$

To determine $\rho_N^T(n)$, we will first derive $\rho_1^T(0)$ and $\rho_1^T(1)$. According to Figure 1, the probability of a single central banker being highly efficient in the second period is made up of three factors. First, nature determines whether a central banker is highly efficient in the first period. Second, re-appointment takes place. Third, nature

[18]The subscript N in $\rho_N^T(n)$ denotes the size of the council. This notation will allow the construction of a recursion formula.

determines whether a newly appointed central banker is highly efficient or not. We obtain the following expression:

$$\rho_1^T(1) = \frac{1}{2}\cdot p\cdot 1 + \frac{1}{2}\cdot(1-p)\cdot\frac{1}{2} + \frac{1}{2}\cdot\frac{1}{2}\cdot\frac{1}{2} \tag{20}$$

$$= \frac{1}{4}p + \frac{3}{8} \tag{21}$$

It is now easy to derive $\rho_1^T(0)$:

$$\rho_1^T(0) = 1 - \rho_1^T(1) \tag{22}$$

$$= -\frac{1}{4}p + \frac{5}{8} \tag{23}$$

For $p = 1/2$ we obtain $\rho_1^T(0) = \rho_1^T(1) = 1/2$, which is plausible since, for $p = 1/2$, both types are indistinguishable and thus occur with equal probability. Having determined $\rho_1^T(0)$ and $\rho_1^T(1)$, we can construct $\rho_N^T(n)$ by observing that the probability of a single central banker being highly efficient in the second period depends neither on the total number of central bankers N nor on the number of highly efficient central bankers n. We thus obtain the binomial expression

$$\rho_N^T(n) = \binom{N}{n}\left(\rho_1^T(1)\right)^n\left(\rho_1^T(0)\right)^{N-n} \tag{24}$$

5.3 Comparison

We compare social losses in the second period using the following proposition:

Proposition 10
Losses in the second period are always smaller under transparency.

Proof
By comparing $\rho_N^T(n)$ and $\rho^O(n)$ it can be shown that the distribution of competent central bankers in the second period under transparency first-order stochastically dominates the respective distribution under opacity. While this is more or less obvious, because governments can distinguish the competence of central bankers more easily under transparency, we have not been able to adopt a formal proof. Our numerical simulations, however, show that first-order stochastic dominance holds for all $N < 50$ and $0.5 < p < 1$. Since $P(n)$ is (weakly) increasing in n, we obtain $\sum_{n=0}^{N}\rho_N^T(n)P(n) > \sum_{n=0}^{N}\rho^O(n)P(n)$, i.e., the probability of good monetary policy in the second period is higher under transparency than under opacity. This immediately implies that second-period social losses are higher under opacity.

□

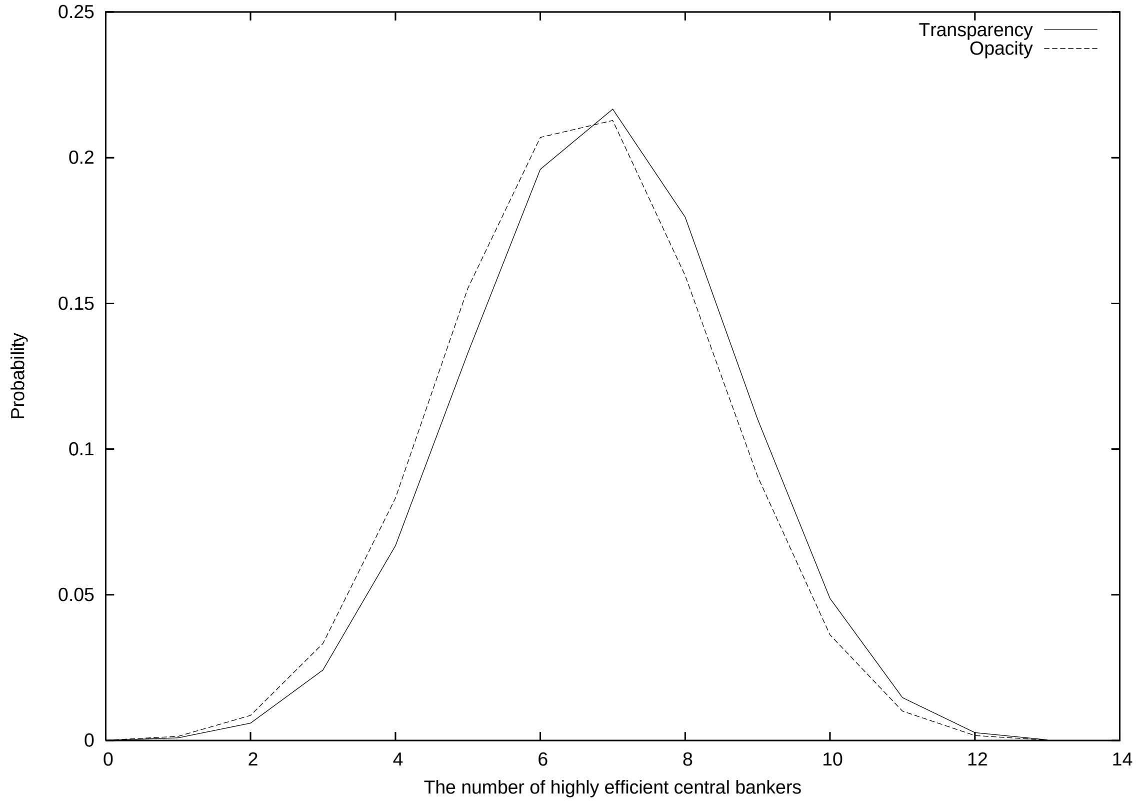

Figure 2: $\rho_N^T(n)$ and $\rho^O(n)$ for $p = 0.6$ and $N = 13$.

Since transparency makes the re-appointment process more efficient, there are usually more highly efficient central bankers in the second period under transparency than under opacity. Consequently, more highly efficient central bankers increase the likelihood of a good decision, which lowers social losses under transparency.

It may be interesting to compare $\rho_N^T(n)$ and $\rho^O(n)$ for a specific example. Figure 2 shows these probabilities for $N = 13$ and $p = 0.6$. Figure 3 shows the respective c.d.f.'s. It is clear that first-order stochastic dominance holds in this case. It is also important to note that while transparency usually guarantees more highly efficient central bankers in the second period, the effect is not very large.

6 Overall Comparison

So far, we have established that under opacity losses are lower in the first period but larger in the second. Thus, the final step is to compare overall losses. While it is hard to compare losses analytically due to the complexity of the respective expressions, the terms can be calculated numerically for any probability p and any number of central-

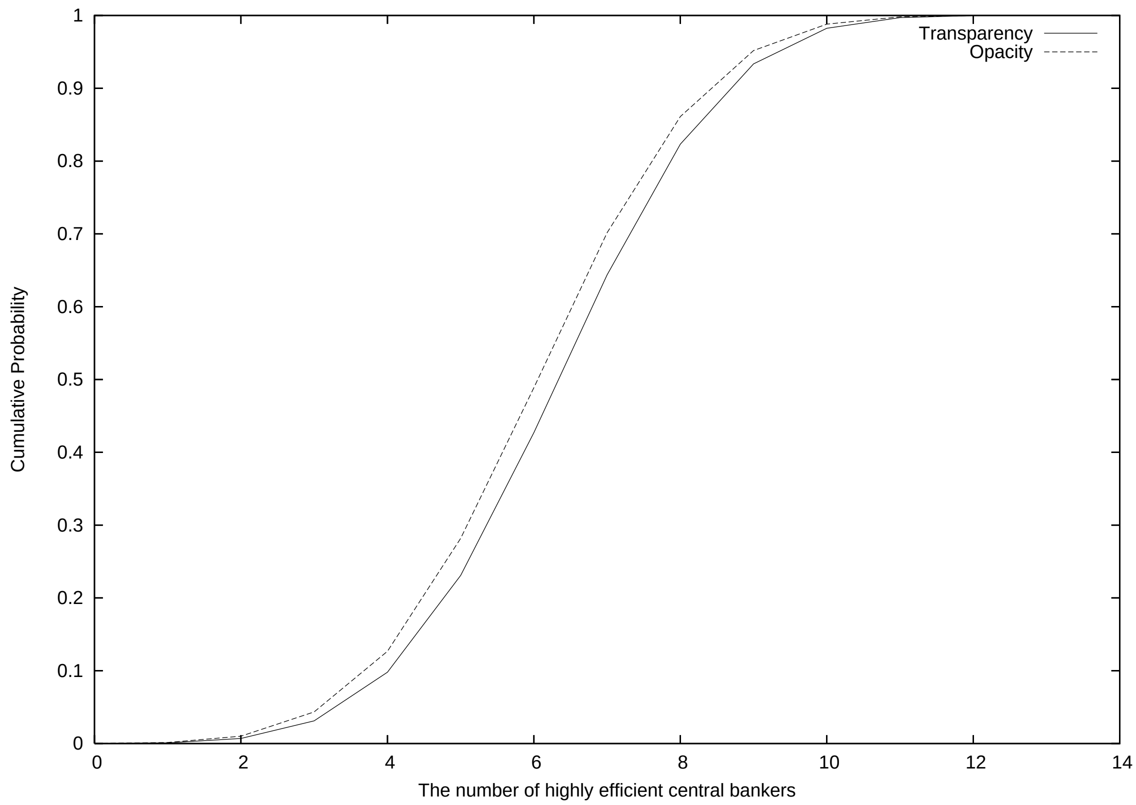

Figure 3: The respective c.d.f.'s for the distribution of highly efficient central bankers under transparency and opacity

bank council members N. As an example, Figure 4 shows social losses for both periods and under both scenarios as a function of N for the parameter $p = 0.8$.

Losses always decrease when N increases, as the likelihood becomes greater that the central bank will take correct decisions. We also see that under each scenario losses are smaller in the second period compared to the first period because under both scenarios the average number of highly efficient central bankers is larger in the second period. A larger average number of highly efficient central bankers also lowers second-period losses under transparency compared to second-period losses under opacity. However, first-period losses under transparency are rather large, since fewer efficient members actively partake in decision making. For $N = 1$ it does not matter whether we consider transparency or opacity. Therefore social losses under both scenarios are always identical for $N = 1$.

Since the above pattern holds for different values of p, we summarize our main comparison as follows:

Numerical Finding 1
If $N > 1$, overall expected losses are always larger under transparency no matter how large the discount rate δ, $0 < \delta < 1$.

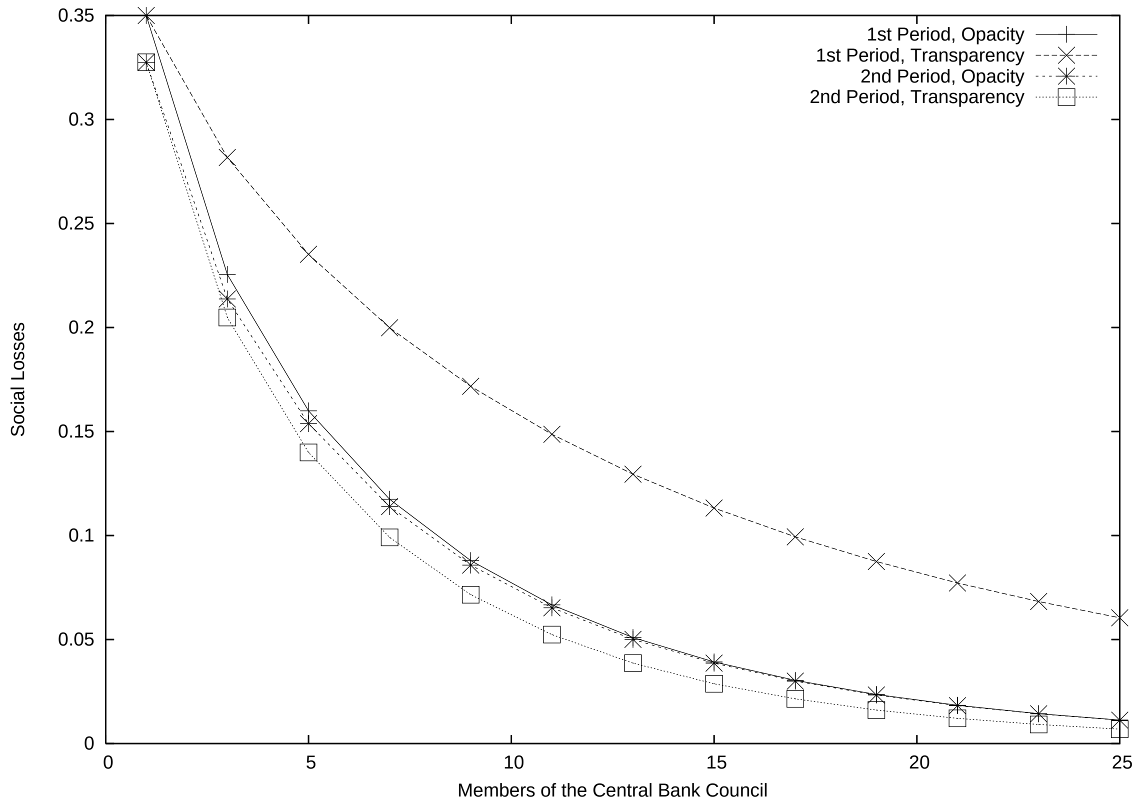

Figure 4: Social losses depending on the number of central bankers.

This result is supported by our numerical analysis but the expressions are so complex that no analytical proof is available. While transparency always reduces second period losses, it always increases first period losses. It is not clear a priori which effect dominates. However, our numerical computations indicate that for any $p > 1/2$ and $N > 1$ the absolute value of the difference of first period losses always exceeds the absolute value of the difference of losses in the second period. Therefore we can conclude that overall expected losses are always larger under transparency, independently of the parameter δ.

In order to provide intuition for our results we start from the two effects of transparency. First, transparency distorts the behavior of less efficient central bankers who want to be re-appointed. This is socially detrimental. Second, transparency makes it easier to identify and re-appoint highly efficient central bankers. This increases welfare over time. However, it is much less obvious why (and under which circumstances) the first effect has a stronger impact on welfare than the second effect.

The beneficial impact of transparency is weakened by three effects. First, under transparency highly efficient central bankers may also be dismissed if their signals are wrong. Second, less efficient central bankers have a 50% chance of not being detected and thus being re-appointed. Third, even if a central banker's low level of efficiency is revealed under transparency, there is a 50% percent chance of his being replaced by another less efficient central banker. Moreover, the council can be dismissed under opacity, which in this case also increases the expected number of highly efficient central bankers over time. On balance, the advantage of transparency is not sufficient to outweigh the costs created by the signaling incentives for less efficient central bankers.

To provide deeper intuition, the following thought experiment reveals that the second and third effects alone have a sufficiently weakening impact on the beneficial effect of transparency to make opacity preferable. The thought experiment runs as follows: We consider a less efficient individual central banker in the first period of the game. Suppose that all other central bankers behave as under opacity and that they are always re-appointed. Suppose that the government can choose between two options concerning the behavior of the less efficient central banker under consideration:

(o) The central banker behaves as under opacity in the first period and is always re-appointed.

(t) The central banker behaves as under transparency in the first period and is always replaced by a successor whose probability of being highly efficient is 1/2.

This thought experiment captures the basic tradeoff identified in our paper. In the following, we assume that the discount factor is $\delta = 1$, which favors transparency.

Now let us define H_{-1} (H_{+1}) as the probability of the highly efficient council members voting for the wrong (correct) interest rate with a majority of one vote. Similarly, let H_0 be the probability of the highly efficient council members reaching a draw. These three cases are crucial, as they imply that the vote of the central banker under consideration actually matters. Note that these probabilities are identical in both periods, because in our thought experiment all other central bankers are always re-appointed.

Transparency creates a reduction in the probability of a beneficial outcome in the first period. This reduction is given by

$$-H_{-1} \cdot \left(\frac{1}{2} \cdot \frac{1}{2}\right) + H_0 \cdot \left(\frac{1}{2} - \frac{1}{2}\right) + H_{+1} \cdot \left(\frac{1}{2} \cdot \frac{1}{2}\right) \qquad (25)$$

For example, the term $-H_{-1} \cdot \left(\frac{1}{2} \cdot \frac{1}{2}\right)$ refers to the case where the rest of the central bankers votes for the wrong interest rate by a majority of one vote. If the central banker under consideration randomizes between both interest rates, he will choose the correct rate with a probability of 1/2. Then a draw is reached and the correct interest rate is chosen with a probability of 1/2. The sign "−" represents the fact that this effect *increases* the probability of a correct outcome.

In an analogous manner we can derive the increase in the probability of a beneficial outcome in the second period as

$$H_{-1} \cdot \left(\frac{1}{2} \cdot p \cdot \frac{1}{2}\right) + H_0 \cdot \frac{1}{2} \cdot \left(p - \frac{1}{2}\right) - H_{+1} \cdot \frac{1}{2} \cdot (1-p) \cdot \frac{1}{2} \tag{26}$$

The government prefers (o) to (t) if (25) is larger than (26). This can be restated as

$$(2-p)H_{+1} > (1+p)H_{-1} + (2p-1)H_0 \tag{27}$$

Interestingly, it is straightforward to derive

$$H_{+1} = \frac{p}{1-p} H_{-1} \tag{28}$$

Intuitively, the difference between case +1 and case −1 is that one highly efficient committee members switches from a correct vote to a wrong vote. The relative probability between an individual member voting for the correct vote as opposed to the wrong vote is $\frac{p}{1-p}$.

Using (28), we can simplify (27) as follows:

$$H_{+1} > pH_0 \tag{29}$$

As a consequence, (29) holds if $H_{+1} > H_0$, which means that a small majority for the correct interest rate is more likely than a draw. This condition holds intuitively (highly efficient central bankers are more likely to vote for the correct interest rate than the wrong interest rate) and can also be verified analytically. To sum up, a government that can choose between behaviors (t) and (o) of an individual central banker will choose (o). Thus in our thought experiment the distortion in the first period is more significant than the positive effect induced by the dismissal of a less efficient member in the second period.

The comparison in our paper is more complicated than in our thought experiment as the council can be dismissed under opacity and highly efficient central bankers may be dismissed accidentally under transparency. Moreover, less efficient central bankers may remain undetected and thus be re-appointed. These effects, however, tend to strengthen the social value of opacity over transparency.

7 Conclusion

In this paper we have identified the costs and benefits of voting transparency, concluding that the costs may be large enough to justify opacity. This conclusion is not restricted to central-bank councils; it could also be applied to other committees consisting of members with different degrees of competence, identical utility functions, and the desire to be re-appointed due to the large private benefits this implies.

The disadvantage of transparency in our model stems from the signaling incentives of less efficient central bankers, which has broad parallels in other economic areas, notably in signaling games (see e.g. Kreps and Sobel (1994)).[19] Transparency, though, has the advantage of revealing inefficiencies more successfully than opacity.

Our finding that opacity is superior to transparency extends to a model where the prior probabilities for $I^* = -1$ and $I^* = +1$ are different. In this case, the possibility of re-appointment may induce a small distortion to the behavior of less efficient central bankers even under opacity. However, this distortion is not strong enough to reverse our finding about higher social losses under transparency.[20]

It is interesting to ask why the government does not constrain the term in office for central bankers to one period under transparency. Then there would be no need for less efficient central bankers to randomize, which would yield lower losses. This re-appointment behavior, however, would not be time-consistent, as it is ex-post optimal in the beginning of the second period to re-appoint central bankers who have voted for the correct interest rate. If it is possible to eliminate the possibility of re-appointment, it is beneficial to do so. Introducing only one, possibly very long term in office destroys the possibility of re-appointing central bankers who have shown desirable voting behavior. More importantly, however, it induces less efficient central bankers to behave in a socially optimal way and to refrain from socially inefficient attempts to get re-appointed. Under opacity, it is optimal if the council can always be re-appointed as many times as possible. This guarantees that successful councils can be left in office for many periods.

It may also be interesting to explore from an ex ante point of view whether central bankers would prefer transparency over opacity. Our model suggests the following: Under transparency less efficient central bankers have a probability of one half of getting re-appointed. Under opacity the probability of getting re-appointed is higher. Therefore incompetent central bankers prefer opacity to transparency. A similar argument holds for highly efficient central bankers. Thus from an ex ante point of view both less efficient central bankers and highly efficient central bankers prefer opacity

[19]The concern about pressure to appear highly efficient in every decision has also been raised in private communications with central-bank council members and individuals involved in central-bank design. Cukierman (2001) has expressed concern that, when votes are published, decisions will depend more on political and personal considerations and less on professional considerations.

[20]Since the analysis of this case is very lengthy, we do not give the proof here. It is available upon request.

to transparency. This implication of our model may explain why central bankers are sometimes reluctant to impose transparency on monetary policy.

We have simplified our model by assuming that only one decision is made during one term of central bankers. Thus the decision stage in our model should be interpreted as a representative decision taken during one term. However, it seems plausible that this simplification should not affect the basic effects identified in our model, namely that transparency enables the government to identify competent individuals more easily, while creating more incentives for central bankers to appear as competent individuals.

One prediction of our model is that transparency leads to more controversial voting in central bank councils, as somewhat less competent central bankers play a more active role in the decision-making process.[21] In principle, this could be verified empirically if one assumes that, where voting records are published with substantial delay, central bankers act as if voting records remain secret. The claim by ECB Council Members that decisions are taken by consensus may offer some anecdotal evidence that opacity can lead to less controversial voting because somewhat less competent central bankers play a more passive role and follow the majority.

Of course, we do not claim that the model in this paper captures all aspects of voting transparency. For example, "on-the-job-learning" may be important for central bankers, which might make it less likely for central bankers to be replaced for lack of competence. Transparency may also increase central bankers' efforts to acquire information. We also show in Gersbach and Hahn (2004) that our findings might be reversed if differences in preferences are crucial. It is also conceivable that central bankers would circumvent a transparency requirement by meeting in secret before the official meeting.[22] Nevertheless, we believe that our model provides an interesting example of an effect that is often overlooked, i.e. that transparency may alter the incentives of decision-makers in monetary policy committees by creating a conflict between socially desirable and individually optimal behavior. This may well distort policy decisions in an unfavorable way. Hence, we find some support for the fear raised by central bankers that transparency may hamper open-minded discussion between council members and thus render monetary policy-making less efficient.

[21] Cf. also Stasavage (2006), who shows that transparency may lead to greater polarization of opinions when decision-makers are subject to lobbying.

[22] This poses the question of whether transparency would be feasible. Our focus is designed to answer the question whether transparency is desirable in principle.

A Proof of Proposition 5

It is plausible (and can be verified later by examining the expressions for welfare in the second period under transparency) that the government can ensure the maximum possible welfare in the second period by maximizing the likelihood of high efficiency for each individual central banker. Consequently, it is optimal to re-appoint only central bankers who are highly efficient with a probability that is higher than the probability of a newly appointed member being highly efficient. Suppose that highly efficient central bankers behave according to Proposition 4 and less efficient central bankers choose $+1$ (-1) with probability σ_i ($1-\sigma_i$). Then the probability of a central banker being highly efficient, given that he has voted for the correct (C) or wrong (W) interest rate, played an active (A) or passive (P) role and given that $+1$ or -1 was the correct interest rate, is given by

$$\kappa^T_{+1,C,A} = \frac{p}{\sigma_i + p} \tag{30}$$

$$\kappa^T_{+1,W,A} = \frac{1-p}{1-\sigma_i+1-p} \tag{31}$$

$$\kappa^T_{-1,C,A} = \frac{p}{1-\sigma_i+p} \tag{32}$$

$$\kappa^T_{-1,W,A} = \frac{1-p}{\sigma_i+1-p} \tag{33}$$

Note that, for $I^* = +1$, our assumption (6) can only be fulfilled if $\kappa^T_{+1,C,A} \geq \kappa^T_{+1,W,A}$, which entails $\sigma_i \leq p$. Similarly, assumption (6) requires $\kappa^T_{-1,C,A} \geq \kappa^T_{-1,W,A}$ for $I^* = -1$, and thus, in turn, $\sigma_i \geq 1-p$. Since $0 < \sigma_i < 1$, we can conclude that, in equilibrium, any less efficient central banker must be indifferent between choosing $+1$ and -1. Otherwise randomizing would not be optimal.

A less efficient central banker is indifferent with respect to voting for $+1$ or -1 if both options entail the same probability of re-appointment and if both options guarantee the same probability of a correct outcome in the first period. The first condition can be stated as

$$\frac{1}{2}\mu^T_{+1,C,A} + \frac{1}{2}\mu^T_{-1,W,A} = \frac{1}{2}\mu^T_{-1,C,A} + \frac{1}{2}\mu^T_{+1,W,A} \tag{34}$$

The sum on the left-hand side gives the probability of a highly efficient central banker being re-appointed if he chooses $+1$. The right-hand side gives the respective probability for the vote -1.

For the second condition, we need to introduce $D_I(\sigma_1, \sigma_2, .., \sigma_{i-1}, \sigma_{i+1}, ..., \sigma_N)$, which is the probability that there is a draw in the group of all central bankers without central banker i if the correct interest rate is I and if each highly efficient central banker votes for the correct interest rate with probability p and if each less efficient central banker votes for +1 with probability σ_j. Note that, because of the symmetry of the problem, any permutation of the arguments of D_I does not affect its value. Moreover, the following condition holds:

$$D_{-1}(\sigma_1, \sigma_2, .., \sigma_{i-1}, \sigma_{i+1}, ..., \sigma_N) = D_{+1}(1-\sigma_1, 1-\sigma_2, .., 1-\sigma_{i-1}, 1-\sigma_{i+1}, ..., 1-\sigma_N) \quad (35)$$

The probability of a draw is crucial as central banker i only has an impact on the outcome of the vote if there is a draw among the rest of the central bankers. The probability of a beneficial outcome when central banker i chooses +1 equals the respective probability if the central banker chooses −1. Hence, the following equation holds for each central banker i:

$$D_{+1}(\sigma_1, \sigma_2, .., \sigma_{i-1}, \sigma_{i+1}, ..., \sigma_N) = D_{-1}(\sigma_1, \sigma_2, .., \sigma_{i-1}, \sigma_{i+1}, ..., \sigma_N) \quad (36)$$

which can be reformulated as

$$D_{+1}(\sigma_1, \sigma_2, .., \sigma_{i-1}, \sigma_{i+1}, ..., \sigma_N) = D_{+1}(1-\sigma_1, 1-\sigma_2, .., 1-\sigma_{i-1}, 1-\sigma_{i+1}, ..., 1-\sigma_N) \quad (37)$$

It is obvious that $\sigma_i = 1/2 \ \forall i = 1...N$ is a solution to these N equations. However, it remains to be shown that this solution is unique.

For example, let us consider the equation for $i = 1$ and for $i = 2$.

$$\begin{aligned} D_{+1}(\sigma_2, \sigma_3, ..., \sigma_N) &= D_{+1}(1-\sigma_2, 1-\sigma_3, ..., 1-\sigma_N) \quad (38)\\ D_{+1}(\sigma_1, \sigma_3, ..., \sigma_N) &= D_{+1}(1-\sigma_1, 1-\sigma_3, ..., 1-\sigma_N) \quad (39) \end{aligned}$$

We will show later that $\frac{\partial}{\partial \sigma_j} D_{+1}(\sigma_2, \sigma_3, ..., \sigma_N) \leq 0 \ \forall j = 2..N$. Similarly, $\frac{\partial}{\partial \sigma_j} D_{+1}(1-\sigma_2, 1-\sigma_3, ..., 1-\sigma_N) \geq 0 \ \forall j = 2..N$. We will also show that the first inequality holds with equality only if $\sigma_i = 1-p \quad \forall i = 1..N, i \neq j$. Moreover the second inequality holds with equality only if $\sigma_i = p \quad \forall i = 1..N, i \neq j$. Consequently, for each $j = 2..N$ at least one of the inequalities holds strictly.

As a consequence, if equation (38) has a solution for σ_2, given $\sigma_3, \sigma_4, ...\sigma_N$, this solution is unique. Then given $\sigma_3, \sigma_4, ...\sigma_N$ equation (39) implies the same unique solution for σ_1. Thus we establish that all σ_i's are identical. Let σ be the respective value. Then (37) simplifies to

$$D_{+1}(\sigma, \sigma, ..., \sigma) = D_{+1}(1-\sigma, 1-\sigma, ..., 1-\sigma) \quad (40)$$

Now we can write

$$D_{+1}(\sigma, \sigma, ..., \sigma) = \binom{N-1}{\frac{N-1}{2}} \left(\frac{1}{2}(p+\sigma)\right)^{\frac{N-1}{2}} \left(1 - \frac{1}{2}(p+\sigma)\right)^{\frac{N-1}{2}} \quad (41)$$

where we have taken account of the fact that each individual central banker casts a correct vote with probability $\frac{1}{2}(p+\sigma)$, given that $+1$ is correct. This probability is the sum of $\frac{1}{2}p$, which is the probability of a central banker being highly efficient and casting a correct vote, and $\frac{1}{2}\sigma$, which is the probability of a central banker being less efficient and casting a correct vote.

With (41) equation (40) can be stated as

$$\left(\frac{1}{2}(p+\sigma)\right)\left(1-\frac{1}{2}(p+\sigma)\right)=\left(\frac{1}{2}(p+1-\sigma)\right)\left(1-\frac{1}{2}(p+1-\sigma)\right) \tag{42}$$

which implies

$$\sigma=\frac{1}{2} \tag{43}$$

We now need to demonstrate our earlier claim that $\frac{\partial}{\partial\sigma_j}D_{+1}(\sigma_2,\sigma_3,...,\sigma_N)\leq 0\ \forall j = 2..N$. Note that, given that $I^*=+1$, the probability of an individual central banker i voting correctly in the first period amounts to $\gamma_i := \frac{1}{2}(\sigma_i+p)$ with $\gamma_i\geq\frac{1}{2}$ (which follows from $\sigma_i\geq 1-p$). Let us consider, without loss of generality, $j=2$. We can write

$$D_{+1}(\sigma_2,\sigma_3,...,\sigma_N)=\gamma_2 d_- + (1-\gamma_2)d_+ = \frac{1}{2}(\sigma_2+p)\,d_- + \left(1-\frac{1}{2}(\sigma_2+p)\right)d_+ \tag{44}$$

where we have introduced d_- (d_+) as the probability that, among members $i=3...N$, a majority of exactly one member votes for -1 ($+1$). We obtain

$$\frac{\partial}{\partial\sigma_2}D_{+1}(\sigma_2,\sigma_3,...,\sigma_N)=\frac{1}{2}(d_- - d_+) \tag{45}$$

Because $\gamma_i\geq\frac{1}{2}$, i.e. the probability of each player $i=3...N$ voting for $+1$ is higher than the respective probability of the player voting for -1, $d_+\geq d_-$ holds, which implies $\frac{\partial}{\partial\sigma_2}D_{+1}(\sigma_2,\sigma_3,...,\sigma_N)\leq 0$. The inequality $d_+\geq d_-$ holds only with equality if $\sigma_i = 1-p \quad \forall i=1..N, i\neq j$, which implies $\gamma_i = 1/2 \quad \forall i=1..N, i\neq j$.

□

B Proof of Proposition 6

In the proof of Proposition 5, we have defined the probability of a central banker being competent. Using this definition and applying $\sigma_i = 1/2$ and $p > \frac{1}{2}$, we obtain

$$\kappa^T_{+1,C,A} = \frac{p}{\frac{1}{2}+p} > \frac{1}{2} \tag{46}$$

$$\kappa^T_{+1,W,A} = \frac{1-p}{\frac{1}{2}+1-p} < \frac{1}{2} \tag{47}$$

$$\kappa^T_{-1,C,A} = \frac{p}{\frac{1}{2}+p} > \frac{1}{2} \tag{48}$$

$$\kappa^T_{-1,W,A} = \frac{1-p}{\frac{1}{2}+1-p} < \frac{1}{2} \tag{49}$$

It is only optimal for the government to re-appoint a central banker if he is more likely to be competent than a newly appointed colleague. Thus we obtain the proposed re-appointment scheme.

For completeness, we also give the out-of-equilibrium beliefs of the government. If a central banker chooses a passive role and is correct (C) or wrong (W), and if I is the optimal interest rate, then the respective probability of a central banker being highly efficient is given by

$$\kappa^T_{I,X,P} < 1/2 \qquad \forall I \in \{-1,+1\}, X \in \{C,W\} \tag{50}$$

The out-of-equilibrium beliefs $\kappa^T_{I,X,P}$ ensure that it is optimal to dismiss any central banker who has played a passive role.

It is straightforward to verify that the re-appointment scheme satisfies (12) and (34), which implies that the central bankers behave optimally given the re-appointment scheme.

□

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