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MONETARY POLICY COMMITTEES

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In 2009 all ECB publications feature a motif taken from the €200 banknote.

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CONTENTS

Abstract

Monetary Policy Committees differ in the way the interest rate proposal is prepared and presented in the policy meeting. In this paper we show analytically how different arrangements could affect the voting behaviour of individual MPC members and therefore policy outcomes. We then apply our results to the Bank of England and the Federal Reserve. A general finding is that when MPC members are not too diverse in terms of expertise and experience, policy discussions should not be based on pre-prepared policy options. Instead, interest rate proposals should arise endogenously as a majority of views expressed by the members, as is the case at the Bank of England and appears to be the case in the FOMC under Chairman Bernanke.

Keywords: monetary policy committee, voting, Bank of England, Federal Open Market Committee.

JEL Classification: E58, D71, D78.

Non-technical summary

Central banking has undergone a tremendous transformation over the last twenty years (see (Blinder 1998, 2004)). A prominent example is the collective character of policy decision-making, see also BIS (2009). According to Fry et al. (2000), in the late 1990s 79 out of 88 surveyed central banks had committees to make policy decisions. Central banking by committee by now has become the rule rather than the exception. Whether or not this results in better monetary policy however is not clear. As noted by the political science literature, the superiority of committee decision making can depend on for example the voting rule used, see e.g. Nitzan and Paroush (1985). Practitioners, most prominently Blinder (2004, 2007), however, take a rather benign view, by arguing that collective monetary policy decision making should result in better outcomes, due to the pooling of information, models and expertise.

This paper adds to the rapidly growing literature on monetary policy committee decision making by investigating analytically whether an observed difference between the procedures applied by real monetary policy committees, the organization of the interest rate meeting, and in particular the origin and timing of the interest rate proposal, has a bearing on the policy outcome. We focus our study on two of the most influential monetary policy authorities in the world, i.e. the Bank of England's Monetary Policy Committee and the Federal Open Market Committee. This is also because these central banks provide a large amount of information about the policy-making cycle. They moreover provide information that allows for empirically testing our conclusions, i.e. attributed votes and even verbatim transcripts of discussions (in the case of the Federal Open Market Committee).

The stylized monetary policy committee meeting begins with a presentation of recent economic and financial developments by central bank staff, updating the reports that were disseminated to all members before the meeting. Then members discuss the economic outlook and, subsequently, the appropriate policy stance. Finally, a policy proposal is put to a vote. The proposal can be prepared a priori (in our model – by the Board), which is the tradition in the Federal Open Market Committee, or can be made by the Chair to reflect the majority of views presented in the meeting, which seems to be the tradition in the Monetary Policy Committee of the Bank of England.

A major contribution of our paper is the modelling approach, constituting a merger between two strands of modelling collective decision-making processes and their outcomes: the traditional statistical approach and the new game-theoretic one. We have modelled the interest rate meeting as a game among rational decision makers, who independently form their views on the economic situation and the necessary interest rate decision. The statistical approach influence in our model is the independent nature of the views, based on the signals about the state of the economy independently sent by nature to all decision makers, and the assumption that the policy decision can be reduced to a binary choice: a change or no change in interest rates.

The game-theoretic influence is the rationality assumption, meaning that the decision makers do not mechanistically vote in line with their views (or: the signals they have received). In our model the decision makers choose their actions in the meeting (votes) such that those actions maximize their expected utility from the committee's decision, on the basis of their judgment of the state of the economy and voting strategies they expect others to follow. Our setup is hence a modification of the seminal work of Austen-Smith and Banks (1996) and Feddersen and Pesendorfer (1998) on juries.

Our results show that the organization of the monetary policy committee meeting and the timing of the interest rate proposal are not immaterial to the actions of the committee members and hence to policy outcomes. For example, the announcement of a prior policy proposal early in the meeting, before members have revealed their preferred policy options, could actually give rise to three possible voting equilibria: (1) A herding equilibrium, where all members vote in favour of (follow) the Board's interest rate proposal. The proposal is adopted with no dissents. In this case, the proposal acts as a common signal and crowds out the members' private information, in analogy to the seminal result by Morris and Shin (2002). (2) An informative equilibrium, where the Board supports its proposal but other members ignore the proposal and vote in line with their private preferred policy options. The proposal may be overruled if the Board has no majority in the committee. Most likely there will be dissents among non-Board committee members at the voting stage. (3) A cheap-talk equilibrium, where even the Board does not automatically support the prior proposal in the policy meeting; all members vote in line with their private preferred policy options. The proposal is irrelevant for the final policy outcome; it's only function is to enlarge the information set of all committee members. Almost certainly there will be dissents among the members at the voting stage.

1 Introduction

Central banking has undergone a tremendous transformation over the last twenty years (see (Blinder 1998, 2004)). A prominent example is the collective character of policy decision-making. According to Fry et al.(2000), in the late 1990s 79 out of 88 surveyed central banks had committees to make policy decisions. Central banking by committee by now has become the rule rather than the exception, see also BIS (2009). Whether or not this results in better monetary policy however is not clear. Theory suggests that collective decision making consistent with optimal individual behaviour requires MPC members to condition their votes on those of their colleagues. And, as noted by the political science literature, the superiority of committee decision making can depend on for example the voting rule used, see e.g. Nitzan and Paroush (1985). The early economic literature on collective decision making in a monetary policy context noted that preferences and strategic considerations between committee members might adversely affect the quality of collective monetary policy outcomes (see e.g. Waller (1989, 1992), Von Hagen and Süppel (1994), Grüner (1999), Hefeker (2003) and Sibert (2003)). More recently, Blinder (2004, 2007) takes a more benign view, by arguing that collective monetary policy decision making should result in better outcomes, due to the pooling of information, models and expertise.

This paper adds to the rapidly growing literature on monetary policy committee (henceforth: MPC) decision making by starting from the stylized fact that in reality MPCs around the world operate differently and are organized differently, see Fry et al. (2000), Lybek and Morris (2004) or Maier (2007). These differences span many dimensions, such as size, composition of membership, decision-making rules and the way the meeting is structured. Some of these differences have been shown to have an impact on the behaviour of MPC members. Gerlach-Kristen (2003) for example showed that different types of members of the Monetary Policy Committee of the Bank of England (internal vs external members) differ in the frequency and the duration of dissents, and in preferences to dissent for lower or higher policy rates. Bhattacharjee and Holly (2005), Spencer (2006) and Groth and Wheeler (2008), among others, have shown that these dissents can be explained by varying sensitivities to changes in macroeconomic situation, to deviations of inflation forecasts from the target and to differences in the way individual members assimilate information supplied to them (different 'mind-sets'). Chappell et al. (2005) report results analogous to Gerlach-Kristen (2003) for the US. Further, Chappell et al. (2004, 2005, 2007a, 2007b) have shown the effects of a strong chairman on the Federal Open Market Committee (FOMC) members' interest rate proposals. Meade and Sheets (2005) documented the effects of regional background on individual FOMC members' interest rate proposals. Finally, Meade and Stasavage (2008) showed the effects of a publication of verbatim transcripts of the FOMC meetings on the debate among the members.

Our contribution is that we investigate analytically whether an observed

difference between MPCs of influential central banks (of the US and UK), i.e. the origin and timing of the interest rate proposal, has a bearing on the policy outcome.[1] The stylized MPC meeting begins with a presentation of recent economic and financial developments by central bank staff, updating the reports that were disseminated to all members before the meeting. Then members discuss the economic outlook and, subsequently, the appropriate policy stance. Finally, a policy proposal is put to a vote. The proposal can be prepared a priori, which is the case in the Federal Open Market Committee, or can be made by the Chair to reflect the majority of views presented in the meeting, which seems to be the case at the Monetary Policy Committee of the Bank of England. We show that, if the proposal is presented early in the meeting, it can act as a common signal and crowd out the members' private information, in analogy to the seminal result by Morris and Shin (2002). We subsequently show that this can have adverse effects on the prior probability that the MPC reaches correct policy decisions. In most cases, it is preferable not to have a prior policy proposal at all.

We start in the next section by discussing the practice and stylized facts of monetary policy decision making in the FOMC and the Bank of England's Monetary Policy Committee. It will become clear that, at least under some chairmen, those central banks differ substantially in terms of the origin and timing of the interest rate proposal to be voted on by the MPC. We will then turn, in section 3, to a model that allows us to analyze the consequences of these differences for the voting behaviour of individual members. The predictions of this model are presented and discussed in section 4. Section 5 concludes. Formal analysis is presented in an Appendix.

2 Decision-making cycle of a monetary policy committee

To highlight the relevance of differences in organizational arrangements between MPCs, we study two of the most influential monetary policy authorities in the world, i.e. the Bank of England's Monetary Policy Committee and the Federal Reserve System's FOMC. [2] The Monetary Policy Committee publishes minutes and attributed votes, while the FOMC publishes minutes, votes and even verbatim transcripts of discussions.

The Bank of England's Monetary Policy Committee is made up of nine members – five internal members (the Governor, the two Deputy Governors, the Bank's Chief Economist and the Executive Director for Markets) and four external members, appointed to ensure that the Committee benefits from external thinking and expertise in addition to that gained inside the Bank of

[1] To avoid confusion between any MPC and the Monetary Policy Committee of the Bank of England, in the text we will always write out the full name of the latter.

[2] These central banks also provide a large amount of information about their functioning. They are not unique in that respect, however, as the same could be said for the central banks of, say, the euro area, Japan, Sweden, Norway or New Zealand. Some of these central banks differ from the Federal Reserve and Bank of England in that they have monetary policy deliberations that focus on future paths of interest rates. We sidestep the latter issue, as it is beyond the scope of this paper.

England. The Committee meets every month.

The policy cycle begins on Friday before the Monetary Policy Committee meeting with a briefing session, known as 'the pre-MPC meeting'. In this meeting the Bank of England staff presents the important economic news of the previous month. The meeting also includes reports from the Bank's regional agents on the information they received from their business contacts around the country. The pre-meeting is attended by all Committee members "...so that they can prepare for the following week's policy meeting on an equal footing..." (BoE, 2006, p. 7).

The policy meeting takes two days, typically Wednesday and Thursday. On the first day, the committee discusses the economic situation, with each member giving his or her view or interpretation. "... Wednesday is not a time for actually discussing the interest rate decision itself. Rather, it is the moment for exploring the different issues which will help to shape each member's decision the following day. Members never talk to each other at any time about what they are likely to do when the votes are cast on Thursday morning. Instead, they reach their decision in their own way, and in their own minds..." (BoE, 2006, p. 11). On Thursday, the interest rate decision is taken. First, the Governor speaks "...summarizing the previous day's discussion in a balanced and neutral way. He does not attempt to direct the outcome of the meeting. [...] After each person has spoken, the Governor invites questions: he himself speaks, and votes, last.[3] The decision goes to the majority and there is no attempt to arrive at a consensus: members are individually accountable for their decisions..." (BoE, 2006, p.11-12). It is clear from this description that there is no attempt to arrive at a high degree of consensus; the decision goes to the majority.[4] Hence, we observe (see Table 1 below, data obtained from the website of the Bank of England) quite a high share of voting dissents among the Committee members.

	% meetings with dissents	AVG % dissents per meeting
Governor George	58%	22%
Governor King	62%	20%

Table 1. Monetary Policy Committee voting dissents under Governors George and King (period July 1997 - July 2008)

The US Federal Reserve has different arrangements. Its Federal Open Market Committee consists of twelve members – seven members of the Board of Governors of the Federal Reserve System, the president of the Federal

[3]According to BoE (2006), this practice was started by Governor George and is now maintaned by Governor King.

[4]This behaviour is in practice facilitated (if not encouraged) by the fact that the members of the Monetary Policy Committee of the Bank of England are individually - not collectively - accountable. Note, however, that in our theoretical model, as described in the following section, we will assume that each committee member cares about the accuracy of the collective decision, not about the accuracy of her individual vote.

Reserve Bank of New York and four of the remaining eleven Reserve Bank presidents, who serve on a rotating basis. The FOMC meets eight times per year.

The policy cycle of the FOMC also begins in the week preceding the policy meeting (typically on Thursday) with the circulation of the Greenbook containing the staff's forecast and analysis of the outlook as well as a detailed analysis of recent developments in the economy and financial markets. The next document circulated before the FOMC meeting (typically about mid-morning on Saturday) is the Bluebook, containing two or three policy options, that will be presented in the meeting. On Monday before the FOMC meeting the Federal Reserve Board holds a meeting, where the staff makes a more detailed presentation of the outlook to the Board. The presidents are briefed by their own staffs (briefings that may include separate forecasts prepared within the regional reserve banks) and also get copies of the briefings presented to the Board by its staff each week..." (Meyer, 1998). According to Meyer (2004), the Monday morning Board meeting has also been used by Chairman Greenspan to communicate his views to Board members and garner support for them (p. 50-51). The FOMC meeting begins on Tuesday with presentations by the staff. This is followed by a general discussion where "...Each member of the FOMC presents his or her own views on the outlook [...] The current practice is that Bank presidents generally go first, because they have information that the governors do not have – information about developments in their own regions...". At this stage, Bank presidents also comment on the Greenbook forecasts, conveying (when relevant) also the forecasts prepared within the regional central banks. The FOMC then turns to policy. This round begins with the presentation on policy options by the Director of Monetary Affairs. Then the FOMC members express their views. There is no fixed speaking order. Chairman Greenspan used to go first, which gave him "...the opportunity to lead the Committee, both toward the position he is advocating and toward a consensus...." (Meyer, 1998) Chairman Bernanke, on the other hand, is believed to speak last (Wall Street Journal (2006)). After this policy round, the Chairman makes the consensus policy proposals and votes first on it.

Table 2 below presents summary statistics for the dissents in the preferred policy rates among FOMC members (what we call deliberation dissents) under Chairmen Burns and Greenspan, calculated on the basis of the data from Chappell et al. (2007a, 2005). In parentheses we also present voting data. The table illustrates a very high occurrence of dissents under Chairman Burns. This would support the claim of Romer and Romer (2004), that, Chairman Burns had "rapidly fluctuating and often unrealistic views".

	% meetings with dissents	AVG % dissents per meeting
Chairman Burns	93% (37%)	58% (14%)
Chairman Greenspan	65% (50%)	25% (15%)

Table 2. FOMC deliberation (voting) dissents under Chairmen Burns and Greenspan (period February 1970 - February 1978, August 1987 - December 1996)

Notwithstanding the differences between Chairmen Burns and Greenspan, the proportion of deliberation dissents is still substantial. However, using the voting data, the number and frequency of dissents is much smaller (especially when one extends the time sample for Chairman Greenspan to include his whole tenure, i.e. until January 2006; the share of meetings with dissents then drops to 36%) probably illustrating the tradition of supporting the Chairman.

The description above represents, to the best of our knowledge, the actual functioning of both MPCs. It illustrates that the (voting) behaviour of its members differ. Moreover, the FOMC and the Monetary Policy Committee differ regarding the origin of the interest rate proposal, with the FOMC using a pre-prepared proposal (or set of options) as a basis for discussion and the Monetary Policy Committee voting on a proposal that follows more or less endogenously from the preceding discussions. This difference is more general, as the survey of Maier (2007) shows: in 11 out of 30 central banks surveyed the proposal is prepared a priori and presented in the meeting, the remainder having either other arrangements or no formal arrangements. Given this plethora of observed arrangements, we are interested in investigating whether these differences are material in that they affect the behaviour of individual MPC members. To this end, we will in the next section construct a model that captures the most important elements of a meeting of a MPC. Such a meeting is preceded by a dissemination of macroeconomic reports to all its members, written by central bank staff. The meeting begins with the presentation of recent economic and financial developments by the staff. Then MPC members begin their discussions, first with the economic outlook and then specifically regarding the appropriate interest rate. The discussion closes with a vote on a policy proposal. The proposal can be prepared a priori by either staff or the Board, which to the best of our knowledge seems to be the case in the FOMC, or not, which seems to be the case at the Monetary Policy Committee of the Bank of England. It seems a priori obvious that, when the prior proposal is made, the timing of its presentation in the MPC meeting becomes important. The proposal can be made at the beginning of policy discussions or just before the voting round, after other MPC members have had a chance to reveal their views on the appropriate policy action. The MPC will then decide on a majority basis.

3 The MPC game

Our objective is to analyze the effects of the origin and timing of the policy proposal on the voting behaviour of MPC members. Our MPC is diverse as defined by Hong and Page (2001, 2004) in that its members have limited abilities and differ in the way they encode and approach problems. This heterogeneity between members is closely related to what Blinder (2007) describes as different mind sets. It provides the basis for an explanation of why collective effort can outperform the individual: by virtue of being different, individuals can improve upon each other's solution to a problem. Applied to an MPC with a single mandate, e.g. to maintain price stability, individual members differ in translating the (commonly) available economic information into risks to price stability (different perspectives) and in the way of dealing with the identified risks to price stability (different heuristics). Bringing these diverse individuals together in a MPC meeting then enlarges the set of all different ways of solving a problem, that is: taking the correct monetary policy decision. This description of diversity is widely accepted in the field of organizational behaviour, and Bhattacharjee and Holly (2005) provide empirical evidence of the relevance of these differences for the case of the MPC in the UK. The diversity of views believed to increase the benefits from collective decision-making (see Blinder (2004, 2007)) is in many cases grounded in law. Take the US FOMC. Regarding the Board, the Federal Reserve Act states "...In selecting the members of the Board, not more than one of whom shall be selected from any one Federal Reserve district, the President shall have due regard to a fair representation of the financial, agricultural, industrial, and commercial interests, and geographical divisions of the country..." (Section 10) According to Chairman Bernanke, "...an important strength of the Federal Open Market Committee is its diversity. The Board members and Reserve Bank presidents who sit around the table at each meeting of the FOMC bring a wide range of perspectives to the deliberations that reflect the participants' professional backgrounds, the regions of the country with which they are most familiar, and their differing approaches to economic and policy analysis..." (Bernanke (2007)).[5] The Bank of England's Monetary Policy Committee is also composed of members with different background (internal and external members). "...The argument for including external members is that they bring in a wider range of expertise and experience than would be available if the MPC could draw only on the Bank's own staff. And they bring fresh thinking to the Committee since they are only there for a limited period..." (BoE, 2006, p. 3). In order to focus on these effects and their

[5] To be fair, this paper only looks at the economic implications of committee decision making. It sidesteps the political dimensions. However, the fact is that some MPCs are part of central banks that are organized along federal lines. It has been argued (see Hefeker, 2003) that these central banks and their MPCs reflect a political compromise between regions, that insist on representation, and a board appointed by the central governing body. Thus, the criterion of diversity might also simply reflect the ability to appoint people with certain political preferences.

consequences, they will be investigated in an otherwise purely neutral set-up, where members share objectives and priors. We think that these are reasonable assumptions in the context of MPCs. There might be (and probably are) different personal judgments among members of the MPC about, say, the relative social costs of inflation versus unemployment (and therefore individual preferences might differ). These differences should however be largely irrelevant because the legal mandate of the central bank ought to tell committee members what their loss function is. Of course, when the legal mandate of the central bank is less precise, MPC members have more scope to interpret their mandate differently. The FOMC is a case in point. However, even then we believe that members typically do their best to deliver on these common objectives, if only for reputational reasons (see e.g. Goodhart (2001)). This leads us to conclude that, while it is impossible to exactly identify the reasons for differences in policy recommendations of MPC members, the logic of having a committee to decide on policy suggests that different mind sets is at least as promising a candidate as different preferences. For models where committee members are assumed to have common abilities but different preferences, see e.g. von Hagen and Süppel (1994) and Grüner (1999). Our model is not suited to address both potential sources of heterogeneity simultaneously, as different preferences distort the results regarding the link between the meeting organization, information and the MPC outcome. In the limit, the MPC outcome would solely stem from the relative size of the activist group vs the gradualist group.

We model the MPC meeting as a game among rational decision makers, who choose sequentially rational voting strategies that maximize their expected utility from the committee's decision, on the basis of their judgment of the state of the economy and voting strategies they expect others to follow. As a result we employ models commonly used in the modern jury literature. The formal analysis is presented in the Appendix to this paper. However, given the fact that jury models are relatively new to the economic literature, we give some basic ideas here.[6]

Each committee member cares about taking the correct decision, based on the economic conditions and outlook. The state of the economy is uncertain; the economy can be in either of two states: in state a where economic conditions require a change of the policy rate (decision A), or in state b where the appropriate decision is to keep rates unchanged (decision B). The binary structure is particularly valid for monetary policy decisions, as it is usually fairly clear in what direction interest rates should be moved, if they were to be moved[7], and the size of a move has nowadays become fairly standardized

[6] Our setup is a modification of the seminal work of Austen-Smith and Banks (1996) and Feddersen and Pesendorfer (1998) on juries. Persico (2004) offers a comprehensive overview of the related literature. See Osbourne (2004) for a general discussion of Bayesian games. Gerlach-Kristen (2006) and Meade and Stasavage (2008) constitute other applications of jury and expert models to the analysis of MPCs.

[7] See Gerlach-Kirsten (2007) for empirical evidence corroborating this for the Monetary Policy Committee of the Bank of England.

(25 basis points, with 50 basis points in extreme cases).[8]

Hence, the correct MPC decisions are: decision A in state a and decision B in state b. The utility of each MPC member can be therefore written as:[9]

$$u_i\left(d=A|a\right)=u_i\left(d=B|b\right)=1 \tag{1}$$
$$u_i\left(d=A|b\right)=u_i\left(d=B|a\right)=0 \tag{2}$$

Committee members do not observe the state of the economy. Rather, each of them independently forms judgment on the state of the economy and the appropriate policy decision, based on the shared information and briefings by their own staff. We model this by assuming that each MPC member receives a private independent signal s_i, which imperfectly reveals the state of the economy. Imperfectness of the signal means that receiving information pointing in the direction of decision A gives only q_i certainty that the true state of the economy is a. Formally:

$$P_i(s_i=A|a)=P_i(s_i=B|b)=q_i \tag{3}$$
$$P_i(s_i=B|a)=P_i(s_i=A|b)=1-q_i \tag{4}$$

In our analysis we will interpret q_i as the accuracy of individual judgment. We will assume $0.5<q_i<1$. These restrictions imply that forming a committee to take interest rate decisions is useful.

At any point in time, the set of actions for any MPC member is a set of votes $v_i \in \{A,B\}$. Rationality among MPC members implies selecting voting strategies that maximize their expected utility from the MPC's decision, calculated over all states of the world and all possible actions of other committee members (since the latter affect the collective decision d and therefore the utility of every individual), rather then simply voting in line with their private signals. Rational voting will imply that each committee member will restrict the analysis of her voting strategy to the cases when her vote affects the final outcome, i.e. when it is pivotal (see Austen-Smith and Banks (1996)).

If we denote the probability that an individual member assigns to the economy being in state b conditional on her information as $P(b|\text{info})$, the expected utility from changing interest rates or not (decision A or B) is:

$$\begin{aligned} E\left[u_i\left(d=A\right)\right] &= P(b|info)u_i\left(d=A|b\right)+\left(1-P(b|info)\right)u_i\left(d=A|a\right) \\ &= 1-P(b|info) \end{aligned} \tag{5}$$
$$\begin{aligned} E\left[u_i\left(d=B\right)\right] &= P(b|info)u_i\left(d=B|b\right)+\left(1-P(b|info)\right)u_i\left(d=B|a\right) \\ &= P(b|info) \end{aligned} \tag{6}$$

[8] See also Meade and Stasavage (2008). Recent responses of central banks to the financial turmoil, with a number of central banks changing interest rates by much more, imply that it becomes increasingly difficult to qualify moves of 50 basis points as extreme.

[9] We assume that MPC members' preferences are symmetric: each member considers an inappropriate change in interest rates as bad as inappropriately leaving the policy stance unchanged.

Hence, a rational MPC members will prefer decision B iff

$$P(b|info) > 1 - P(b|info) \Leftrightarrow P(b|info) > 0.5 \tag{7}$$

and A otherwise. The probability $P(b|\text{info})$ depends on all the information that the member has: the information received before the meeting (her own private signal s_i); the information received during the meeting, i.e. the interest rate proposal (or the private signals of other MPC members) if she observes them before she casts her vote; and the information she can deduce about the information possessed (i.e. signals) by other committee members from the assumption that her vote will be pivotal for the MPC's outcome.

As already noted, the interest rate proposal put to a vote in the MPC can originate in two ways: it can be prepared a priori or it can arise from the meeting. In the latter case, it is natural to assume that the proposal represents the majority view of all MPC members and that it is put to vote at the end of the meeting. In the former case, we will assume that the proposal originates as the majority view of the internal members of the MPC (the Board) and emanates as the outcome of the pre-MPC meeting.[10] The prior proposal can in fact be presented at any point in the MPC meeting; in the extreme cases: at the very beginning, i.e. before deliberations, or at the very end, i.e. just before the final vote. The timing of the prior proposal in the MPC meeting affects the voting choices of the MPC members.

The overall structure of the game is as follows. First, all MPC members individually observe their private independent signals about the state of the economy, A or B. Next, the pre-MPC meeting takes place: Board members meet and simultaneously cast their votes, A or B, on a policy proposal for the MPC meeting (at this point their private knowledge consists of their private signals and the information they can deduce from expected pivotality of their votes).[11] The proposal originates as the majority view. Next, the MPC meeting takes place: the Board's proposal is revealed, either before or after other MPC members have revealed their views, and subsequently all MPC members cast their vote (at this point every Board member knows all

[10] This assumption, besides being required for a properly specified voting game in the case of a prior interest rate proposal, has a number of attractive features. Obviously, it allows for a meaningful comparison with the case when no prior proposal is made. Moreover, it can also be easily interpreted as the Chair's proposal.

In the latter situation, one need not distinguish between the accuracy of judgment of the Board and the non-Board members, only between the Chair and the rest of the MPC. This is because the accuracy of judgment of the Board members now becomes irrelevant for the accuracy of the policy proposal; the only relevant judgment is the one of the Chair. Secondly, in this situation there is strictly speaking no need for the pre-MPC meeting - the Chair can simply make her proposal at the beginning of the policy meeting (implying $m = 1$ in our model). Alternatively, one could imagine the pre-MPC meeting to take place purely for the sake of the Chair enforcing her view on other Board members (which is not necessarily a rational approach in our model); in this case m still corresponds to the total number of the Board members (including the Chair) but the accuracy of the proposal remains equal to the accuracy of the Chair's judgment.

[11] See the Appendix for a detailed explanation.

the private signals of Board members, while non-Board members know their private signals and possibly the proposal; all MPC members also have the information they can deduce from expected pivotality of their votes). The MPC decision is again the majority outcome of the vote. Finally, the state of the economy materializes and the payoffs are realized. Note that we make two simplifying assumptions: members do not interact between the voting stages and there is no new information available to the MPC members between the stages of the game.

Note that in an ideal world, with all MPC members sharing common objectives, their superior strategy would be to meet and truthfully reveal all their private signals. The signals should be then aggregated by an appropriate (majority) rule. This would imply that members would reach perfect agreement and would never dissent. However, reality is different. Even though MPC members meet and reveal their information to one another by deliberating, the revelation must be imperfect, since we observe dissents in the voting stage (see section 2). Imperfect revelation of private information can be justified by the fact, that the private information in our set-up goes beyond pure verifiable economic data and encompasses judgmental elements, beliefs about the structure of the economy, 'frames of mind', etc. Information so defined is difficult to share perfectly, and our model captures exactly that.

4 Theoretical predictions

We will start our theoretical contribution by showing what types of equilibria can arise in the MPC voting game when the policy proposal is prepared a priori. We will show that the prior policy proposal has similar effects on MPC members as central bank communication has on private sector agents in the seminal contribution by Morris and Shin (2002). The policy proposal is a common signal observed by all MPC members in the meeting, acts as a focal point and has disproportionately large effects on their voting behaviour, crowding out their private information. We will show that, as in Morris and Shin (2002), it is also likely to lower the MPC members' welfare, defined as the (prior) probability that the MPC will reach the correct policy decision. However, we will also prove the existence of other voting equilibria, which yield higher social welfare. These results are summarized in Proposition 1 below.

Proposition 1 *The announcement of a prior policy proposal early in the MPC meeting, before other MPC members have revealed their preferred policy options, gives rise to three possible voting equilibria:*

1. *A herding equilibrium, where all MPC members follow the prior proposal. The proposal is adopted with no dissents. This equilibrium is more likely to arise, the larger the Board or the larger its judgment advantage relative to non-Board members.*

2. *An informative equilibrium, where the Board supports the prior proposal*

but non-Board members ignore the proposal and vote in line with their private preferred policy options. The proposal may be overruled if the Board has no majority in the MPC. Most likely there will be dissents among non-Board MPC members. This equilibrium is more likely to arise, the smaller the Board and the smaller its judgment advantage relative to non-Board members.

3. *A cheap-talk equilibrium, where even the Board does not support the prior proposal at the voting stage; all MPC members vote in line with their private preferred policy options. The proposal is irrelevant for the MPC's outcome. Almost certainly there will be dissents among Board and non-Board MPC members. This equilibrium is more likely to arise, the smaller the Board and the smaller its judgment advantage relative to non-Board members.*

Intuitively, these results can be linked to the member's utility function, as specified in (1)-(2), that is: their desire to arrive at the correct decision. These preferences imply that rational members look for the best piece of evidence about the state of the economy, depending on what they believe other members will do. Hence, when the Board presents its policy proposal at the beginning of the meeting it is a piece of public information for the non-Board members. If the latter have grounds to believe that the proposal represents a highly accurate signal about the state of the economy (e.g. because they believe the judgment of the Board to be vastly superior and/or because the Board is large), it acts as a focal point (Morris and Shin, 2002) and crowds out their private information in that they rationally choose to forego their own (relatively lesser) judgment and to follow the proposal. Alternatively, if MPC members do not believe that the proposal is highly accurate and/or they expect others to do the same, they may ignore it and stick to their private opinions.

Comparison of figures 1A through 4A in the appendix gives indications that for some combinations of judgment levels and numbers of Board and non-Board members, multiple voting equilibria can exist. We address this issue of multiplicity by assuming that MPC members will choose to play the more efficient equilibrium , i.e. the one which renders a higher accuracy of the MPC's outcome. The upper panel of figure 1 illustrates which equilibria can arise in the MPC game for two 11-member MPCs: one where the Board has majority (of 7 members, left panel) and one where the Board is in minority (of 5 members, right panel). These choices regarding size and composition are only illustrative and motivated by actual MPCs (both the US and the UK for example have committees where the Board is in majority, while Japan and the euro area have committees where the Board is in minority).[12] The horizontal (vertical) axes measure the accuracy of the individual judgment

[12] Figure 1 illustrates that for the size and composition of the MPCs chosen, the differences are relatively small. Larger differences are obtained for more extreme MPCs (both in terms of size and composition), but these are not observed in real life.

of non-Board (Board) MPC members. The dotted area represents the region where the herding equilibrium can arise, the checked one - the informative equilibrium and the shaded one - the cheap-talk equilibrium. The white area represents the region where none of the three equilibria will occur (but other equilibria are possible, as we will discuss below). As expected, we observe that the regions overlap, meaning that multiple voting equilibria are possible.

Figure 1 shows that it is most likely that the MPC game with a prior policy proposal presented at the beginning of the meeting will result in the herding equilibrium. In other words, the presentation of the prior policy proposal at the beginning of the meeting is most likely to result in the MPC adopting the proposal without any dissents. The existence of other equilibria, where at least some of the MPC members vote in line with their private information and possibly dissent from the prior proposal, is far less likely; moreover, they are never unique - they arise under circumstances where the herding equilibrium exists as well.

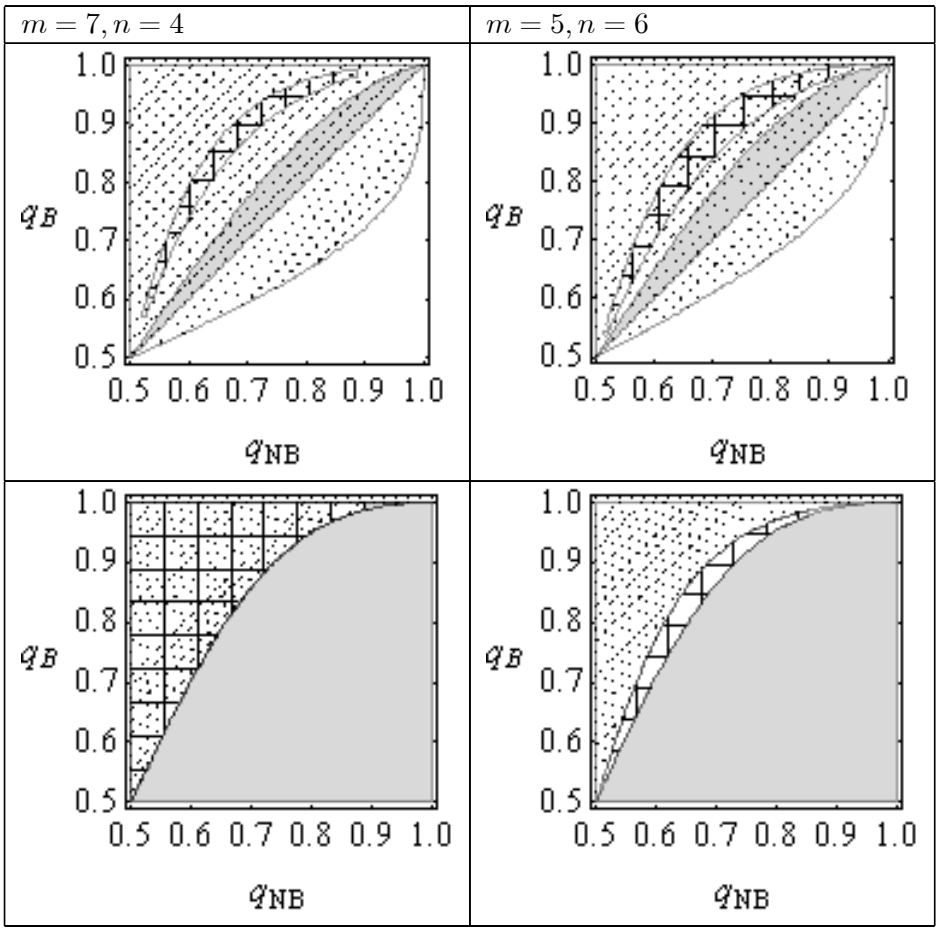

Figure 1. Individual voting equilibria and optimal collective voting behaviour

Notes to Figure 1. m (n) denotes the number of Board (non-Board) members. q_B (q_{NB}) denotes the accuracy of judgment of the Board (non-Board) members. Dotted/checked/shaded areas represent herding/informative/cheap talk (simple majority) equilibria and collective outcomes, respectively.

To see which equilibrium will be played, we need to investigate the accuracy of the MPC decisions achieved in each of the equilibria. These are illustrated in the lower panel of figure 1. The dotted area represents the region where the highest accuracy of the MPC decision is achieved when all MPC members follow the prior policy proposal. The checked area depicts the region where the highest accuracy is achieved when only Board members support the proposal and non-Board members vote in line with their private signals. Finally, the shaded area illustrates the best collective outcomes achieved when all individual MPC members vote in line with their private signals in spite of the prior proposal.[13]

Comparing the upper and lower panels in figure 1 illustrates the Morris and Shin (2002) result, i.e. the disproportionately large effect of the prior policy proposal on the voting behaviour of privately informed MPC members, relatively to the socially desirable outcomes. While the upper panels show that the herding equilibrium is the one that is most likely to arise, the lower panels show that herding is not most likely to result in the highest accuracy of MPC's outcomes. According to the lower panels, the highest accuracy of MPC's outcomes is most likely achieved when all MPC members vote in line with their private information, that is: under pure simple majority. This mismatch between individual and collective incentives can be corrected by an appropriate organization of the MPC meeting. When the (relative) judgment levels of the two types of MPC members fall into the shaded regions in the lower panels, there should be no prior policy proposal prepared for the MPC meeting; the proposal should arise endogenously as a majority position of the opinions expressed by the members in the meeting.

Regarding the cases when the highest accuracy of MPC decisions is achieved when Board members support the proposal but non-Board members vote in line with their private information, the upper and lower panels show that the individual and social incentives are relatively well aligned; the checked areas appear to overlap. However, it can be shown that this is not a general result: the smaller the Board and the larger the number of non-Board members, the larger the misalignment of the incentives. Again, one can correct this mismatch by an appropriate organization of the MPC meeting: when

[13] In the situation when the Chair alone prepares and presents the policy proposal, the configuration of the best collective outcomes in the case without the pre-MPC meeting is similar to the left panel in figure 1, with q_B measuring the judgment of the Chair (although now the informative equilibrium outcomes are equal to the simple majority outcomes). In the case of the pre-MPC meeting being used by the Chair to enforce her view in the Board, the configuration of the best collective outcomes is similar to the right panel in figure 1, with q_B measuring the judgment of the Chair (although the dotted area, where the herding equilibrium outcomes dominate, is much smaller).

the (relative) judgment levels fall into the checked regions in the lower panels, the proposal should be prepared prior to the MPC meeting but in the meeting it should be presented later, after non-Board members have revealed their preferred policy options. The MPC should moreover agree to adopt the prior proposal only if a sufficient number of non-Board members have expressed the same preference before hearing the proposal. This agreement will increase the likelihood of an informative equilibrium to arise, as Proposition 2 below shows.

Proposition 2 *The announcement of a prior policy proposal late in the MPC meeting, after non-Board MPC members have revealed their preferred policy options, allows for the informative voting equilibrium to arise for* $0.5 < q_{NB} < 1$, $0.5 < q_B < 1$ *and all committee sizes. It requires that the MPC agrees to adopt the prior proposal iff at least* $\frac{n+m+1}{2} - m$ *non-Board MPC members have independently expressed preference for the same policy option.*

Summarizing, we have shown that when the prior policy proposal is presented early in the MPC meeting, the most likely scenario is that all MPC members will choose to follow it and the proposal will be adopted without dissents. This scenario, however, need not deliver the highest accuracy of MPC decisions, especially if the judgment level of the non-Board members is high. The mismatch can be corrected by an appropriate design of the MPC meeting, for example by having no prior policy proposal at all. The superiority of any of the arrangements depends on the (relative) judgment levels of the two types of MPC members. This relationship, illustrated in the lower panels of figure 1, is quantified in table 3 below, which shows the probabilities that a particular organization of the MPC meeting yields the highest accuracy of the collective decision, given the judgment level of the non-Board members. The table illustrates clearly that in general the best meeting structure is not to have a policy proposal at all (unless the judgment of the non-Board members is very poor). The table also shows that the interim option of preparing the policy proposal in advance but postponing its presentation to the end of the MPC meeting is not very likely to yield superior outcomes. This is in general because of a fine marginal balancing between the benefits of delegating the decision to the Board with on average better judgment on the one hand, and using all members' individual independent information on the other.

	No prior proposal	Proposal late	Proposal early
$0.5 \leq q_{NB} \leq 0.6$	21%	8%	71%
$0.6 \leq q_{NB} \leq 0.7$	58%	12%	30%
$0.7 \leq q_{NB} \leq 0.8$	83%	6%	11%
$0.8 \leq q_{NB} \leq 0.9$	95%	2%	3%
$0.9 \leq q_{NB} \leq 1.0$	99%	0%	1%

Table 3. Distribution of superior meeting organizations ($m = 5, n = 6$)

See notes to Figure 1.

4.1 Uncertainty about MPC members' judgment

The above analysis assumed that MPC members are certain about the level of each other's expertise. We now relax this restriction and assume that the accuracy of individual judgment cannot be perfectly assessed or observed by other committee members, although it can be correctly assessed by the individual herself.[14] Formally, we will assume that q_B and q_{NB} cannot be observed, but rather q_B^{obs} and q_{NB}^{obs} defined as:

$$q_{NB}^{obs} = q_{NB} + \varepsilon_{NB} \tag{8}$$

$$q_B^{obs} = q_B + \varepsilon_B \tag{9}$$

where it still holds that $0.5 < q_{NB}^{obs} < 1$ and $0.5 < q_B^{obs} < 1$. ε_B, ε_{NB} are IID zero-average assessment errors.

The assumption of imperfectly observable judgment implies that policy-making may suffer from errors, where the assessment of the policy-makers' judgment is important. In our voting model, a correct assessment is relevant for the collective outcome in two ways. It first of all affects members' choices of rational voting strategies and, consequently, the existence of voting equilibria. It secondly affects the selection between multiple equilibria: when multiple individual voting equilibria are possible, the individual MPC member will play the one that she expects will deliver the most accurate collective decision. Of course, the actual quality of the MPC decision will depend on the true judgment of members (this quality is depicted in the lower panels of figure 1).[15] We illustrate these two effects in figure 2 below, drawn for two 11-member MPCs, as in figure 1 (one where the Board has majority - left panel, and one where the Board is in minority - right panel), and under the assumption of a relatively small degree of uncertainty: $q_B^{obs} \rightarrow U[q_B - 0.05, q_B + 0.05]$ and $q_{NB}^{obs} \rightarrow U[q_{NB} - 0.05, q_{NB} + 0.05]$ (e.g. non-Board members believing that Board members' judgment accuracy is between 70 and 80 per cent and vice versa). Note that, to satisfy the conditions $0.5 < q_{NB}^{obs} < 1$ and $0.5 < q_B^{obs} < 1$, figure 3 must be drawn for the true judgments $0.55 < q_{NB} < 0.95$ and $0.55 < q_B < 0.95$. Hence it is somewhat zoomed in relative to figure 1.

The interpretation of the upper panel in figure 2 is analogous to figure 1: it depicts regions where the various individual voting equilibria can occur. The comparison of the two figures shows that the uncertainty seems to have little effect on the existence of the voting equilibria. However, this is not a general result: with higher uncertainty the existence of the cheap-talk (or:

[14] Uncertain level of judgment has not been frequently modeled in the jury literature. Recent related work includes Visser and Swank (2007).

[15] In formal terms, uncertainty about one another's judgment implies that rationality conditions for different voting strategies, as described in the appendix, will be specified in terms of random variables q_M^{obs} and q_N^{obs} and will have to be solved as integrals (unless the random variable cancels out). The comparison of collective outcomes under different meeting organisations will also be done in terms of random variables q_M^{obs} and q_N^{obs} and will have to be solved as integrals.

simple majority) equilibrium with early prior proposal becomes less likely than under certainty; the existence of the herding equilibrium is hardly affected while the region where the informative equilibrium exists is somewhat shifted. Intuitively, faced with uncertainty about each other's judgment, MPC members become less likely to vote independently in the MPC meeting (under cheap-talk with prior proposal, the assessment of the informational content of pivotal situations becomes particularly difficult for both types of MPC members; this issue is less relevant in the herding equilibrium, where no member expects to be pivotal, and in the informative equilibrium, where no Board member expects to be pivotal).

The lower panels in figure 2 depicts regions where both types of MPC members (Board and non-Board) estimate a particular individual voting strategy (herding (dotted region), informative (checked region), and cheap talk (shaded region)), to generate the highest accuracy of the MPC decision, treating the judgment of the other group as uncertain. In other words, this panel is the benchmark that members use for determining which of the multiple equilibria they will play. Comparison to the lower panels in figure 1 reveals that uncertainty also has an effect on the ordering and selection of equilibria. In general, uncertainty introduces a wedge in the preferences for a particular equilibrium between the two types of MPC members: Board members more often assess the herding equilibrium as superior while non-Board members (uncertain about the quality of the policy proposal) are more likely to see the cheap-talk (or: simple majority) outcomes as superior. Since a particular outcome must be selected by both types of members, the general effect of uncertainty on the ordering of equilibria is the following: the higher the uncertainty, the larger the reduction in the regions where particular equilibria would be chosen by all MPC members and the larger the regions where no equilibrium could be chosen. Hence, a proper meeting organization becomes even more crucial under uncertainty, which introduces coordination issues between MPC members.

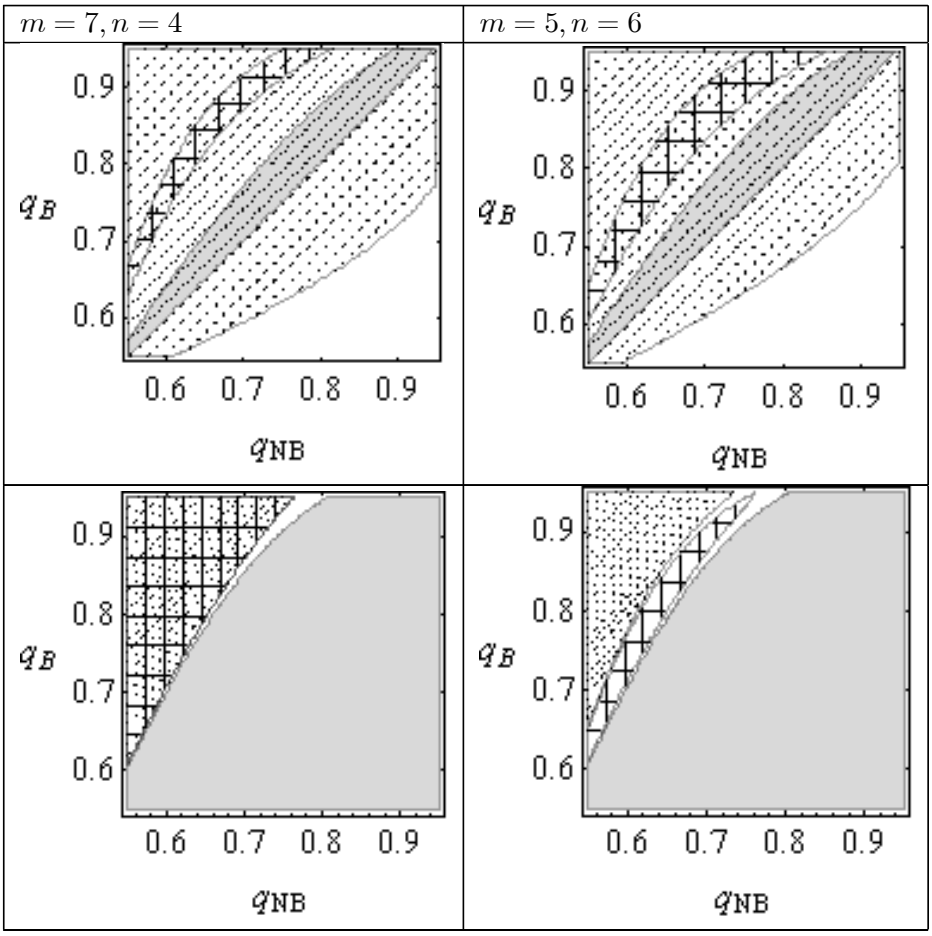

Figure 2. Individual voting equilibria and optimal collective voting behaviour under uncertainty

See notes to Figure 1.

5 Concluding observations

The organization the MPC meeting and the timing of the interest rate proposal are not immaterial to policy outcomes. Under certain conditions, maximizing the quality of monetary policy dictates that the proposal should be made prior to the MPC meeting. Alternatively, the proposal should emanate from the discussion during the meeting, as an aggregation of the views expressed by all the members. Our analysis indicates that the latter is almost always preferable.

Applying our findings to real life monetary policy committees, it seems that the central banking profession has generally become better at judging the state of the economy and choosing appropriate policy actions, meaning that all MPCs have been moving towards the upper right corner in figures 1 and 2 in the previous section. That means that nowadays the dominance

of an expert chairman, or any other individual MPC member, is more likely to have detrimental effects for policy than in the past. Indeed, our analysis suggests that MPCs comprised of members that can be considered experts in the field of monetary policy, should be set up in a way that best ensures an individualistic (voting) behaviour.

While the main motivation of this research is based on real life, i.e. monetary policy committees of the US Federal Reserve and the Bank of England, our analysis is highly stylized and contains some important caveats. This should be kept in mind when interpreting our results. Our analysis assumes rationality of MPC members, which requires substantial cognitive (and computing) capacities that our MPC members should be endowed with in order to derive the optimal voting strategies (which becomes obvious upon reading the appendix to this paper). Our analysis allows for one relaxation of this stringent assumption: the possibility of members making errors in the assessment of each others' judgment. We show that the consequences of such errors could potentially be serious (in terms of accuracy of the collective decision). The overall message of this paper therefore is that continued research into the way collective monetary policy decisions making processes are organized is important because such an organization is not immaterial for the quality of monetary policy**.**

Appendix: Formal analysis

Proposition 1. *The announcement of a prior policy proposal early in the MPC meeting, before other MPC members have revealed their preferred policy options, gives rise to three possible voting equilibria:*

1. *A herding equilibrium, where all MPC members follow the prior proposal. The proposal is adopted with no dissents. This equilibrium is more likely to arise, the larger the Board or the larger its judgment advantage relative to non-Board members.*

2. *An informative equilibrium, where the Board supports the prior proposal but non-Board members ignore the proposal and vote in line with their private preferred policy options. The proposal may be overruled if the Board has no majority in the MPC. Most likely there will be dissents among non-Board MPC members. This equilibrium is more likely to arise, the smaller the Board and the smaller its judgment advantage relative to non-Board members.*

3. *A cheap-talk equilibrium, where even the Board does not support the prior proposal at the voting stage; all MPC members vote in line with their private preferred policy options. The proposal is irrelevant for the MPC's outcome. Almost certainly there will be dissents among Board and non-Board MPC members. This equilibrium is more likely to arise, the smaller the Board and the smaller its judgment advantage relative to non-Board members.*

Proof. The proof proceeds as follows. First, we provide the description of the elements of the game, then we define sequentially rational voting strategies and a Perfect Bayesian equilibrium of the voting game. Next, we analyze the voting game with the policy proposal and its equilibria. The analysis proceeds backwards, i.e. first we derive the voting strategies of the MPC members in the MPC meeting and then for the Board members in the pre-MPC meeting (where we assume the prior policy proposal is formulated).

The players in our Bayesian voting game are MPC members, m (odd) Board members and n (even) non-Board members. At the beginning of the game, nature sends private independent signals to all MPC members, $s_i \in \{A, B\}$, hence each member can be of type A or B, depending on the private signal received. The signals are imperfect, as explained in the main text (conditions (3)-(4)).

The set of states is the set of all lists $\{x, s_1, ..., s_{m+n}, P\}$ where $x \in \{a, b\}$ denotes the state of the economy, $s_1, ..., s_{m+n}$ are the private signals of all MPC members, and $P \in \{A, B\}$ is the policy proposal made by the Board in the MPC meeting (which in our model is an 'aggregation' of Board members' private signals).

At each point in time, the set of actions for any type of MPC member is a set of votes $v_i \in \{A, B\}$. All individual votes are then 'aggregated' into a collective decision through a voting rule, which in our model is simple majority. The payoffs from each collective decision are identical for all members and are given by equations (1) and (2) in the main text. The timing of the game is as described in the main text (section 3).

Our solution concept is a Perfect Bayesian equilibrium. Hence, MPC members' strategies will be sequentially rational given their beliefs and the beliefs will be consistent, wherever possible, with the played strategies. A sequentially rational voting (strategy) means that each time an MPC member votes, she chooses a voting strategy that maximizes her expected utility, calculated over all possible states of the world as well as voting strategies she expects other members to follow. It has been shown by Austen-Smith and Banks (1996) that in voting games, each committee member can restrict the analysis of her voting strategy to the cases when her vote affects the final outcome, i.e. when it is pivotal, if such cases exist.[16] In our voting game, with the payoffs specified above, the (sequentially) rational voting strategy for every MPC member is at every stage of the game to support the alternative that is more likely to be correct based on her information and beliefs.

1. Herding equilibrium

Every voting game has a herding equilibrium, where members ignore their private signals and herd behind (follow) a common signal (see also Austen-

[16] The informational content of the fact that a vote is pivotal is determined by the voting rule. In the case of pure simple majority and equal judgment, being pivotal does not provide additional information, since other votes are equally split. This would e.g. not be true under unanimity. For a more detailed analysis of the effects of unanimous voting rules, see Feddersen and Pesendorfer (1998), Coughlan (2000) or Gerardi (2000).

Smith and Banks (1996)). In our game we will define a herding equilibrium as the equilibrium where the rational strategy for all Board members (both type A and B) is to vote in line with their private signals in the pre-MPC meeting and subsequently support the proposal in the MPC meeting. The rational strategy for all non-Board members (both types) is to ignore their private signal and to follow (herd behind) the proposal in the MPC meeting. We will now show that these strategies constitute a Perfect Bayesian equilibrium in our game. Analyzing the game backwards, we start with the choice facing any individual when she is to cast her vote in the MPC meeting.

In line with equation (7) in the main text, every MPC member prefers to support the policy proposal P rather than vote in line with her private signal in the MPC meeting, iff the following conditions are met:[17]

$$P_{i\in NB}(b|P=B, s_i, \text{follow}) \geq 0.5 \tag{10}$$
$$P_{i\in NB}(a|P=A, s_i, \text{follow}) \geq 0.5 \tag{11}$$

for every non-Board member i, and:

$$P_{j\in B}(b|S_B \Longrightarrow B, s_j, \text{follow}) \geq 0.5 \tag{12}$$
$$P_{j\in B}(a|S_B \Longrightarrow A, s_j, \text{follow}) \geq 0.5 \tag{13}$$

for every Board member j. $P_i(x|P = X, s_i$,follow) denotes the probability that the state of the economy is x, conditional on the policy proposal X, member i's private signal s_i, and the information deduced from the belief that all other MPC members will follow the proposal. Since under this belief, an individual vote is never pivotal for the MPC's outcome, it provides no additional information about the state of the world (note the difference with the informative equilibrium below). In the case of Board members we recognize the fact that any member observes the signals of all Board members in the pre-MPC meeting, hence $P_j(x|S_B \Longrightarrow X, s_j$,follow) denotes the probability that the state of the economy is x, conditional on the vector of signals of other Board members S_B implying proposal X , member j's private signal s_j, and the belief that all other MPC members will follow the proposal.

For any non-Board member of type B the above conditional probabilities are given as:[18]

$$P_i(b|P=B, s_i=B, \text{follow}) = \frac{q_{NB}P(P=B|b)}{q_{NB}P(P=B|b)+(1-q_{NB})P(P=B|a)} \tag{14}$$
$$P_i(a|P=A, s_i=B, \text{follow}) = \frac{(1-q_{NB})P(P=A|a)}{(1-q_{NB})P(P=A|a)+q_{NB}P(P=A|b)} \tag{15}$$

[17] See also Austen-Smith and Banks (1996).

[18] Where we assume symmetric priors, i.e. $P(a) = P(b) = 0.5$.

Since our set-up is perfectly symmetric (in the priors, decision-making rules and preferences), the results are symmetric as well. In this case, for example, the derivations for any non-Board member of type A would be the same since:

$$P(b|P=B, s_i=A, \text{follow}) = P(a|P=A, s_i=B, \text{follow})$$
$$P(a|P=A, s_i=A, \text{follow}) = P(b|P=B, s_i=B, \text{follow})$$

where q_{NB} denotes the accuracy of judgment of any non-Board member, and $P(P=B|b)$, $P(P=B|a)$, $P(P=A|a)$ and $P(P=A|b)$, i.e. the information content of the Board's possible policy proposals, are given as:

$$P(P=B|b)=P(P=A|a)=\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^s\left(1-q_B\right)^{m-s} \tag{16}$$

$$P(P=B|a)=P(P=A|b)=\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^{m-s}\left(1-q_B\right)^{s} \tag{17}$$

The non-Board member rationality conditions (10) and (11) can be therefore re-written as:

$$\frac{q_{NB}}{1-q_{NB}}\geq\frac{\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^{m-s}\left(1-q_B\right)^{s}}{\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^{s}\left(1-q_B\right)^{m-s}} \tag{18}$$

$$\frac{q_{NB}}{1-q_{NB}}\leq\frac{\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^{s}\left(1-q_B\right)^{m-s}}{\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^{m-s}\left(1-q_B\right)^{s}} \tag{19}$$

For any Board member of type B, the above conditional probabilities are given as:

$$P_j(b|S_B\Longrightarrow B,s_j=B,\text{follow})=\frac{q_BP(S_B\Longrightarrow B|b,s_j=B)}{\begin{array}{r}\left(q_BP(S_B\Longrightarrow B|b,s_j=B)\right.\\+\left(1-q_B\right)P(S_B\Longrightarrow B|a,s_j=B))\end{array}} \tag{20}$$

$$P_j(a|S_B\Longrightarrow A,s_j=B,\text{follow})=\frac{(1-q_B)P(S_B\Longrightarrow A|a,s_j=B)}{\begin{array}{r}\left(\left(1-q_B\right)P(S_B\Longrightarrow A|a,s_j=B)\right.\\+q_BP(S_B\Longrightarrow A|b,s_j=B))\end{array}} \tag{21}$$

where, under the assumption that they all voted in line with their private signals in the pre-MPC meeting:

$$P(S_B\Longrightarrow B|b,s_j=B)=q_B^x\left(1-q_B\right)^{m-x}\ \text{ for } x=\tfrac{m-1}{2},...,m-1 \tag{22}$$

$$P(S_B\Longrightarrow A|a,s_j=B)=q_B^x\left(1-q_B\right)^{m-x}\ \text{ for } x=\tfrac{m+1}{2},...,m-1 \tag{23}$$

$$P(S_B\Longrightarrow B|a,s_j=B)=q_B^{m-x}\left(1-q_B\right)^{x}\ \text{ for } x=\tfrac{m-1}{2},...,m-1 \tag{24}$$

$$P(S_B\Longrightarrow A|b,s_j=B)=q_B^{m-x}\left(1-q_B\right)^{x}\ \text{ for } x=\tfrac{m+1}{2},...,m-1 \tag{25}$$

Hence, the Board member rationality conditions (12) and (13) can be re-written as:

$$\frac{q_B}{1-q_B}\geq\left(\frac{q_B}{1-q_B}\right)^{m-2x}\ \text{ for } x=\tfrac{m-1}{2},...,m-1 \tag{26}$$

$$\frac{q_B}{1-q_B}\leq\left(\frac{q_B}{1-q_B}\right)^{2x-m}\ \text{ for } x=\tfrac{m+1}{2},...,m-1 \tag{27}$$

To complete the proof of the existence of the herding equilibrium as defined above, we need to show that voting in line with private signals in the pre-MPC

meeting is sequentially rational for all Board members, given the belief that their proposal will be followed in the MPC meeting. Voting in line with her private signal s_j will be rational for any Board member j when the following conditions are met:

$$P_{j\in B}(b|s_j = B, \text{pivotal}) \geq 0.5 \tag{28}$$
$$P_{j\in B}(a|s_j = A, \text{pivotal}) \geq 0.5 \tag{29}$$

where $P_j(x|s_j = X,\text{pivotal})$ denotes the probability that the state of the economy is x, conditional on the private signal X, and the information she can deduce from the case(s) when her vote is pivotal for the MPC's outcome. Since she believes that other Board members will vote in line with their signals and the proposal will be adopted by the MPC, she can rationally expect her vote to be pivotal for the MPC's outcome in one case, i.e. when it makes a difference between the Board adopting proposal A or proposal B. This requires that the votes of other Board members are equally split.

Hence, the above conditional probabilities are given as:

$$P_j(b|s_j = B, \text{pivotal}) = \frac{q_B P_B(\text{pivotal}|b)}{q_B P_B(\text{pivotal}|b)+(1-q_B)P_B(\text{pivotal}|a)} \tag{30}$$
$$P_j(a|s_j = A, \text{pivotal}) = \frac{q_B P_B(\text{pivotal}|a)}{q_B P_B(\text{pivotal}|a)+(1-q_B)P_B(\text{pivotal}|b)} \tag{31}$$

The information content of the pivotality of j's vote under such conditions can be calculated as follows:

$$P_B\left(\text{pivotal}|b\right) = P_B\left(\text{pivotal}|a\right) = q_B^{\frac{m}{2}}\left(1-q_B\right)^{\frac{m}{2}} \tag{32}$$

Hence, we can simplify:

$$P_j(b|s_j = B, \text{pivotal}) = P_j(a|s_j = A, \text{pivotal}) = q_B \geq 0.5 \tag{33}$$

Conditions (18), (19), (26), (27) and (33) specify the region where the herding equilibrium exists for our voting game. Condition (33) is satisfied by assumption. It can be also shown that conditions (18), (26) and (27) are satisfied for all $0.5 < q_{NB} < 1$ and $0.5 < q_B < 1$; only condition (19) is not.[19] The area where condition (19) is satisfied will therefore define the area where the herding equilibrium exists, and is illustrated in figure 1A below.

[19] Conditions (26) and (27) are satisfied for all $0.5 < q_{NB} < 1$ and $0.5 < q_B < 1$ iff $x \geq \frac{m+1}{2}$, i.e. if the votes of Board members other than j were split in favour of one alternative. If $x = \frac{m-1}{2}$, i.e. if the votes were equally split, they would be uninformative about the state of the economy and an individual j would choose to follow her private signal rather than support the proposal.

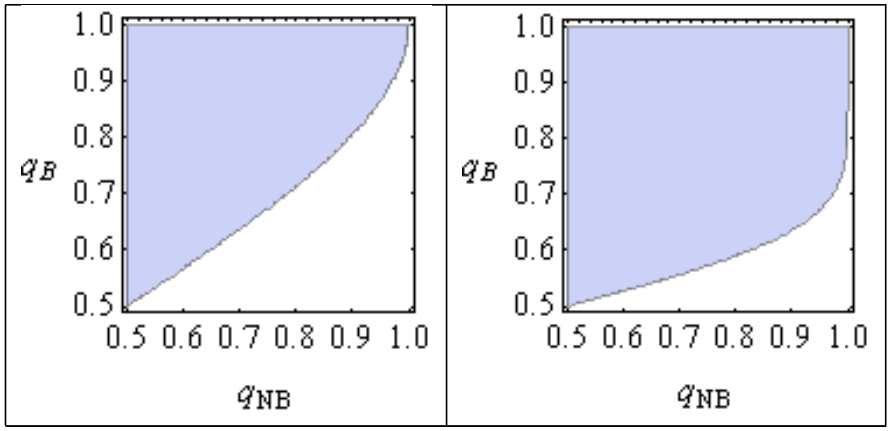

Figure 1A. The herding equilibrium
($m = 3$ - left panel; and $m = 21$ - right panel)

Hence, the herding equilibrium will always exist if Board members have a relative judgment advantage. It is also more likely to exist if the Board is large. This is because both a judgment advantage and a large Board size imply that the policy proposal is very likely to provide a superior signal regarding the state of the economy and it therefore becomes rational for MPC members, who are solely interested in the accuracy of their collective decision, to follow it.

2. Informative equilibrium

We now turn to the question whether our voting game also has an informative equilibrium, defined as the equilibrium where all Board members (both type A and B) vote in line with their private signals in the pre-MPC meeting and support the proposal in the MPC meeting, and all non-Board members (both types) vote in line with their private signals in the MPC meeting (thus ignoring the proposal). Again, we start with the choice facing any individual when she is to cast her vote in the MPC meeting.

For every non-Board member i, voting in line with her private signal s_i and ignoring the Board's proposal is rational iff the following conditions are met:

$$P_{i\in NB}(b|P, s_i = B, \text{pivotal}) \geq 0.5 \tag{34}$$
$$P_{i\in NB}(a|P, s_i = A, \text{pivotal}) \geq 0.5 \tag{35}$$

where $P_i(x|P, s_i = X,\text{pivotal})$ denotes the probability that the state of the economy is x, conditional on the policy proposal P, private signal X, and the information deduced from the case(s) when her vote is pivotal for the MPC's outcome. The belief that all other non-Board members vote in line with their private signals while all Board members will support the proposal P implies that her vote will be pivotal in one case, i.e. when the votes of other non-Board members' are split $\frac{n+m-1}{2} - m$ for the same policy option as the proposal P and $\frac{n+m-1}{2}$ for the other policy option.

Assuming that the Board's proposal is B, the above conditional probabilities can be written out as:

$$P_i(b|P=B, s_i=B, \text{pivotal}) = \frac{q_{NB}P(P=B|b)P_{NB}(\text{pivotal}|b,P=B)}{\left(q_{NB}P(P=B|b)P_{NB}\left(\text{pivotal}|b,P=B\right)\right.} \\ \left. + (1-q_{NB})\,P(P=B|a)P_{NB}\left(\text{pivotal}|a,P=B\right)\right) \tag{36}$$

$$P_i(a|P=B, s_i=A, \text{pivotal}) = \frac{q_{NB}P(P=B|a)P_{NB}(\text{pivotal}|a,P=B)}{\left(q_{NB}P(P=B|a)P_{NB}\left(\text{pivotal}|a,P=B\right)\right.} \\ \left. + (1-q_{NB})\,P(P=B|b)P_{NB}\left(\text{pivotal}|b,P=B\right)\right) \tag{37}$$

The informational content of i's vote being pivotal under such conditions is given as:

$$P_{NB}\left(\text{pivotal}|b,P=B\right) = q_{NB}^{\frac{n+m-1}{2}-m}\left(1-q_{NB}\right)^{\frac{n+m-1}{2}} \tag{38}$$

$$P_{NB}\left(\text{pivotal}|a,P=B\right) = \left(1-q_{NB}\right)^{\frac{n+m-1}{2}-m} q_{NB}^{\frac{n+m-1}{2}} \tag{39}$$

Hence the non-Board member rationality conditions (34)-(35) can be rewritten as follows:

$$\left(\frac{q_{NB}}{1-q_{NB}}\right)^{1-m} \geq \frac{\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^{m-s}\left(1-q_B\right)^s}{\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^{s}\left(1-q_B\right)^{m-s}} \tag{40}$$

$$\left(\frac{q_{NB}}{1-q_{NB}}\right)^{m+1} \geq \frac{\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^{s}\left(1-q_B\right)^{m-s}}{\sum_{s=\frac{m+1}{2}}^{m}\binom{m}{s}q_B^{m-s}\left(1-q_B\right)^{s}} \tag{41}$$

Regarding Board members, we have shown above that supporting the policy proposal in the MPC meeting is always rational for any Board member type, given her beliefs that all other MPC members will follow the proposal as well. The proof of rationality under beliefs that only Board members will support the proposal in the MPC meeting is analogous.

Moving to the pre-MPC meeting, consider the choice facing any Board member j. For the informative equilibrium to exist, we need to prove that voting in line with her private signal s_j in the pre-MPC meeting is rational, given her beliefs that other Board members vote in line with their signals in the pre-MPC meeting and all non-Board members will vote in line with their signals in the MPC meeting. This strategy is sequentially rational iff the following conditions are met:

$$P_{j\in B}(b|s_j=B, \text{pivotal}) \geq 0.5 \tag{42}$$

$$P_{j\in B}(a|s_j=A, \text{pivotal}) \geq 0.5 \tag{43}$$

where $P_j(x|s_j = X$,pivotal) denotes the probability that the state of the economy is x, conditional on the private signal X, and the information she can deduce from the case(s) when her vote is pivotal for the MPC's outcome.

The belief that other Board members will vote in line with their signals in the pre-MPC meeting and non-Board members will vote in line with their signals in the MPC meeting implies that her vote will be pivotal for the MPC's outcome in m cases,[20] i.e. when it makes a difference between the Board adopting proposal A or proposal B while the votes of non-Board members are split in such a way that the Board's proposal will receive the majority of the MPC, i.e. between $\frac{n+m+1}{2} - m$ and $\frac{n+m+1}{2} - 1$ of votes for the same policy option as the proposal and the rest for the other policy option.

Hence, the above conditional probabilities are given as:

$$P_j(b|s_j = B, \text{pivotal}) = \frac{q_B \widetilde{P}_B(\text{pivotal}|b, s_j=B)}{q_B \widetilde{P}_B(\text{pivotal}|b, s_j=B) + (1-q_B)\widetilde{P}_B(\text{pivotal}|a, s_j=B)} \quad (44)$$

$$P_j(a|s_j = A, \text{pivotal}) = \frac{q_B \widetilde{P}_B(\text{pivotal}|a, s_j=A)}{q_B \widetilde{P}_B(\text{pivotal}|a, s_j=A) + (1-q_B)\widetilde{P}_B(\text{pivotal}|b, s_j=A)} \quad (45)$$

The informational content of j's vote being pivotal for the MPC's outcome under such conditions can be calculated as:

$$\widetilde{P}_B\left(\text{pivotal}|b, s_j = B\right) = q_B^{\frac{m}{2}} \left(1 - q_B\right)^{\frac{m}{2}} \sum_{x=\frac{n+m+1}{2}-m}^{\frac{n+m+1}{2}-1} \binom{n}{x} q_{NB}^{x} \left(1 - q_{NB}\right)^{n-x} \quad (46)$$

$$= \widetilde{P}_B\left(\text{pivotal}|a, s_j = A\right)$$

$$\widetilde{P}_B\left(\text{pivotal}|a, s_j = B\right) = q_B^{\frac{m}{2}} \left(1 - q_B\right)^{\frac{m}{2}} \sum_{x=\frac{n+m+1}{2}-m}^{\frac{n+m+1}{2}-1} \binom{n}{x} q_{NB}^{n-x} \left(1 - q_{NB}\right)^{x} \quad (47)$$

$$= \widetilde{P}_B\left(\text{pivotal}|b, s_j = A\right)$$

Hence, the Board member rationality conditions (42)-(43) are equivalent and can be re-written as one:

$$\frac{q_B}{1-q_B} \geq \frac{\sum_{x=\frac{n+m+1}{2}-m}^{\frac{n+m+1}{2}-1} \binom{n}{x} q_{NB}^{n-x} \left(1 - q_{NB}\right)^{x}}{\sum_{x=\frac{n+m+1}{2}-m}^{\frac{n+m+1}{2}-1} \binom{n}{x} q_{NB}^{x} \left(1 - q_{NB}\right)^{n-x}} \quad (48)$$

Again, conditions (40), (41), and (48) specify the region where the informative equilibrium exists. It can be shown that condition (48) is satisfied for any $0.5 < q_{NB} < 1$ and $0.5 < q_B < 1$, m and n; conditions (40) and (41) are not. The area where they are satisfied simultaneously will therefore define the area where the informative equilibrium exists, and is illustrated in figure 2A below.

[20] This is because an individual Board member vote swings the position of the whole m-head Board in the MPC meeting.

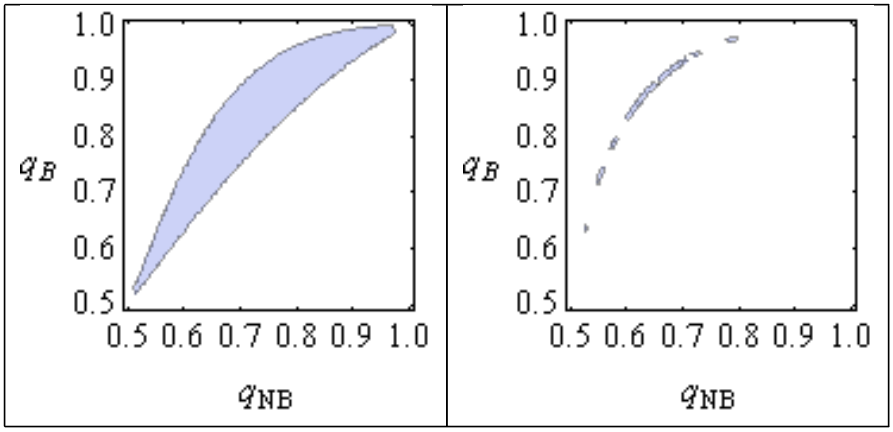

Figure 2A. The informative equilibrium
($m = 3$ - left panel; and $m = 21$ - right panel)

Hence, the informative equilibrium is more likely to exist if the Board is not large and if it has a slight relative judgment advantage, or in other words: if the Board's proposal is not very likely to provide a superior signal regarding the state of the economy. The informative equilibrium will clearly not exist if the Board is large.

3. Cheap-talk equilibrium

We now prove that our voting game also has a cheap-talk equilibrium, i.e. an equilibrium where it is sequentially rational for all Board and non-Board members (both types A and B) to always vote in line with their private signals. Hence, the pre-MPC meeting votes become irrelevant for the MPC's outcome and turn into cheap-talk messages. Again, we start with the choice facing any individual when she is to cast her vote in the MPC meeting.

Every MPC member prefers to vote in line with her private signal, rather than follow the policy proposal, iff the following conditions are met:

$$P_{i\in NB}(b|P, s_i = B, \text{pivotal}) \geq 0.5 \tag{49}$$
$$P_{i\in NB}(a|P, s_i = A, \text{pivotal}) \geq 0.5 \tag{50}$$

for every non-Board member i, and:

$$P_{j\in B}(b|S_B, s_j = B, \text{pivotal}) \geq 0.5 \tag{51}$$
$$P_{j\in B}(a|S_B, s_j = A, \text{pivotal}) \geq 0.5 \tag{52}$$

for every Board member j. $P_i(x|P, s_i = X, \text{pivotal})$ denotes the probability that the state of the economy is x, conditional on the policy proposal P, the private signal X, and the information deduced from the case(s) when her vote is pivotal for the MPC's outcome. Since she believes that all other MPC members will vote in line with their signals, she can rationally expect her vote to be pivotal in one case, i.e. when other votes are equally split. The presentation of the Board's proposal in the MPC meeting will give her additional

information about the pivotal case, as she will know how the Board's majority will vote. In the case of Board members we again recognize the fact that any member observes the signals of all Board members in the pre-MPC meeting, hence $P_j(x|S_B, s_j = X,\text{pivotal})$ denotes the probability that the state of the economy is x, conditional on the vector of signals of other Board members S_B, the private signal X, and the information deduced from the case(s) when her vote is pivotal for the MPC's outcome. When voting in the MPC meeting, the individual Board member uses her knowledge of other Board members' signals in determining the pivotality of her vote, i.e. if the votes of other Board members were split x for one option against $m-1-x$ for the other option in the pre-MPC meeting, she will expect her vote to be pivotal for the MPC's outcome only when non-Board members' votes are split $\frac{n+m-1}{2} - x$ for the same policy option as the x Board members and $\frac{n-(m-1)}{2} + x$ for the other policy option.

Assuming that the Board's proposal is B, the above conditional probabilities for any non-Board member can be written out as:

$$P_i(b|P=B, s_i=B, \text{pivotal}) = \frac{q_{NB}\widetilde{P}_{NB}(\text{pivotal}|b,P=B)}{\left(q_{NB}\widetilde{P}_{NB}\left(\text{pivotal}|b,P=B\right) + \left(1-q_{NB}\right)\widetilde{P}_{NB}\left(\text{pivotal}|a,P=B\right)\right)} \quad (53)$$

$$P_i(a|P=B, s_i=A, \text{pivotal}) = \frac{q_{NB}\widetilde{P}_{NB}(\text{pivotal}|a,P=B)}{\left(q_{NB}\widetilde{P}_{NB}\left(\text{pivotal}|a,P=B\right) + \left(1-q_{NB}\right)\widetilde{P}_{NB}\left(\text{pivotal}|b,P=B\right)\right)} \quad (54)$$

The informational content of the i's vote being pivotal under such conditions is given as:

$$\widetilde{P}_{NB}\left(\text{pivotal}|b,P=B\right) = \sum_{s=\frac{m+1}{2}}^{m} \binom{m}{s} q_B^s \left(1-q_B\right)^{m-s} q_{NB}^{\frac{n+m-1}{2}-s} \left(1-q_{NB}\right)^{n-1-\left(\frac{n+m-1}{2}-s\right)} \quad (55)$$

$$\widetilde{P}_{NB}\left(\text{pivotal}|a,P=B\right) = \sum_{s=\frac{m+1}{2}}^{m} \binom{m}{s} q_B^{m-s} \left(1-q_B\right)^{s} \left(1-q_{NB}\right)^{\frac{n+m-1}{2}-s} q_{NB}^{n-1-\left(\frac{n+m-1}{2}-s\right)} \quad (56)$$

Hence, the non-Board member rationality conditions (49)-(50) can be re-written as follows:

$$\frac{q_{NB}}{\left(1-q_{NB}\right)} \geq \frac{\sum_{s=\frac{m+1}{2}}^{m} \binom{m}{s} q_B^{m-s}(1-q_B)^s(1-q_{NB})^{\frac{n+m-1}{2}-s} q_{NB}^{n-1-\left(\frac{n+m-1}{2}-s\right)}}{\sum_{s=\frac{m+1}{2}}^{m} \binom{m}{s} q_B^s(1-q_B)^{m-s} q_{NB}^{\frac{n+m-1}{2}-s}(1-q_{NB})^{n-1-\left(\frac{n+m-1}{2}-s\right)}} \quad (57)$$

$$\frac{q_{NB}}{\left(1-q_{NB}\right)} \geq \frac{\sum_{s=\frac{m+1}{2}}^{m} \binom{m}{s} q_B^s(1-q_B)^{m-s} q_{NB}^{\frac{n+m-1}{2}-s}(1-q_{NB})^{n-1-\left(\frac{n+m-1}{2}-s\right)}}{\sum_{s=\frac{m+1}{2}}^{m} \binom{m}{s} q_B^{m-s}(1-q_B)^s(1-q_{NB})^{\frac{n+m-1}{2}-s} q_{NB}^{n-1-\left(\frac{n+m-1}{2}-s\right)}} \quad (58)$$

It can be shown that neither of the two above conditions is always satisfied. The area where they are is illustrated in figure 3A below. Hence, it is rational

for non-Board members to vote in line with their private signals in the MPC meeting and ignore the policy proposal if the judgment levels of the two types of members are not too dissimilar, or in other words: if the Board's proposal is not very likely to provide a superior signal regarding the state of the economy. It is less likely to be rational for non-Board members to vote in line with their private signals if the Board is large.

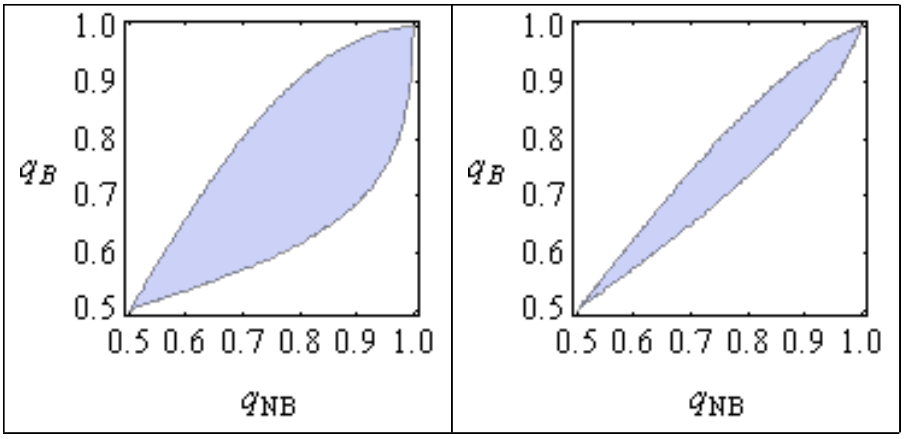

Figure 3A. The cheap-talk equilibrium (I)
($m = 3$ - left panel; and $m = 21$ - right panel)

Turning to Board members, and assuming that the vector of other Board members' votes implies proposal B, the above conditional probabilities are given as:

$$P_j(b|S_B \Longrightarrow B, s_j = B, \text{pivotal}) = \frac{q_B \tilde{\tilde{P}}_B(\text{pivotal}|b, S_B \Longrightarrow B, s_j = B)}{\left(q_B \tilde{\tilde{P}}_B\left(\text{pivotal}|b, S_B \Longrightarrow B, s_j = B\right) + (1 - q_B)\,\tilde{\tilde{P}}_B\left(\text{pivotal}|a, S_B \Longrightarrow B, s_j = B\right)\right)} \tag{59}$$

$$P_j(a|S_B \Longrightarrow B, s_j = A, \text{pivotal}) = \frac{q_B \tilde{\tilde{P}}_B(\text{pivotal}|a, S_B \Longrightarrow B, s_j = A)}{\left(q_B \tilde{\tilde{P}}_B\left(\text{pivotal}|a, S_B \Longrightarrow B, s_j = A\right) + (1 - q_B)\,\tilde{\tilde{P}}_B\left(\text{pivotal}|b, S_B \Longrightarrow B, s_j = A\right)\right)} \tag{60}$$

The information content of the j's vote being pivotal for the MPC's outcome can be calculated as:

$$\widetilde{\widetilde{P}}_B\left(\text{pivotal}|b, S_B \Longrightarrow B, s_j = B\right) = q_B^x \left(1-q_B\right)^{m-x} q_{NB}^{\frac{n+m-1}{2}-x} \left(1-q_{NB}\right)^{\frac{n-(m-1)}{2}+x}$$
$$\text{for } x = \tfrac{m-1}{2}, ..., m-1 \qquad (61)$$

$$\widetilde{\widetilde{P}}_B\left(\text{pivotal}|a, S_B \Longrightarrow B, s_j = B\right) = q_B^{m-x} \left(1-q_B\right)^{x} \left(1-q_{NB}\right)^{\frac{n+m-1}{2}-x} q_{NB}^{\frac{n-(m-1)}{2}+x}$$
$$\text{for } x = \tfrac{m-1}{2}, ..., m-1 \qquad (62)$$

$$\widetilde{\widetilde{P}}_B\left(\text{pivotal}|a, S_B \Longrightarrow B, s_j = A\right) = q_B^{m-x} \left(1-q_B\right)^{x} \left(1-q_{NB}\right)^{\frac{n+m-1}{2}-x} q_{NB}^{\frac{n-(m-1)}{2}+x}$$
$$\text{for } x = \tfrac{m+1}{2}, ..., m-1 \qquad (63)$$

$$\widetilde{\widetilde{P}}_B\left(\text{pivotal}|b, S_B \Longrightarrow B, s_j = A\right) = q_B^x \left(1-q_B\right)^{m-x} q_{NB}^{\frac{n+m-1}{2}-x} \left(1-q_{NB}\right)^{\frac{n-(m-1)}{2}+x}$$
$$\text{for } x = \tfrac{m+1}{2}, ..., m-1 \qquad (64)$$

Hence, the rationality conditions (51) and (52) can be re-written as:

$$\left(\frac{q_B}{1-q_B}\right)^{2x-m+1} \geq \left(\frac{q_{BN}}{1-q_{BN}}\right)^{2x-m+1} \quad \text{for } x = \tfrac{m-1}{2}, ..., m-1 \qquad (65)$$

$$\left(\frac{q_B}{1-q_B}\right)^{m-2x+1} \geq \left(\frac{q_{BN}}{1-q_{BN}}\right)^{m-2x-1} \quad \text{for } x = \tfrac{m+1}{2}, ..., m-1 \qquad (66)$$

It can be shown that these conditions need not be simultaneously satisfied.[21] The area where the conditions are satisfied is illustrated in figure 4A below. Note that the size of the majority of other Board members' votes now becomes important, hence the four panels. It is rational for Board members to vote in line with their private signals in the MPC meeting under two conditions: (i) if the size of the majority of other Board members' votes, that they observed in the pre-MPC meeting, is not too highly informative of the state of the economy (otherwise they would be inclined to follow that majority) and (ii) if they believe that their own judgment is superior to that of non-Board members (otherwise they would be inclined to follow what they believe the majority of non-Board members is). It is clearly not rational for Board members to vote in the MPC meeting against a large majority of the (large) Board as revealed in the pre-MPC meeting.

[21] Unless $x = \frac{m-1}{2}$, when the conditions are satisfied for any $0.5 < q_{NB} < 1$ and $0.5 < q_B < 1$.

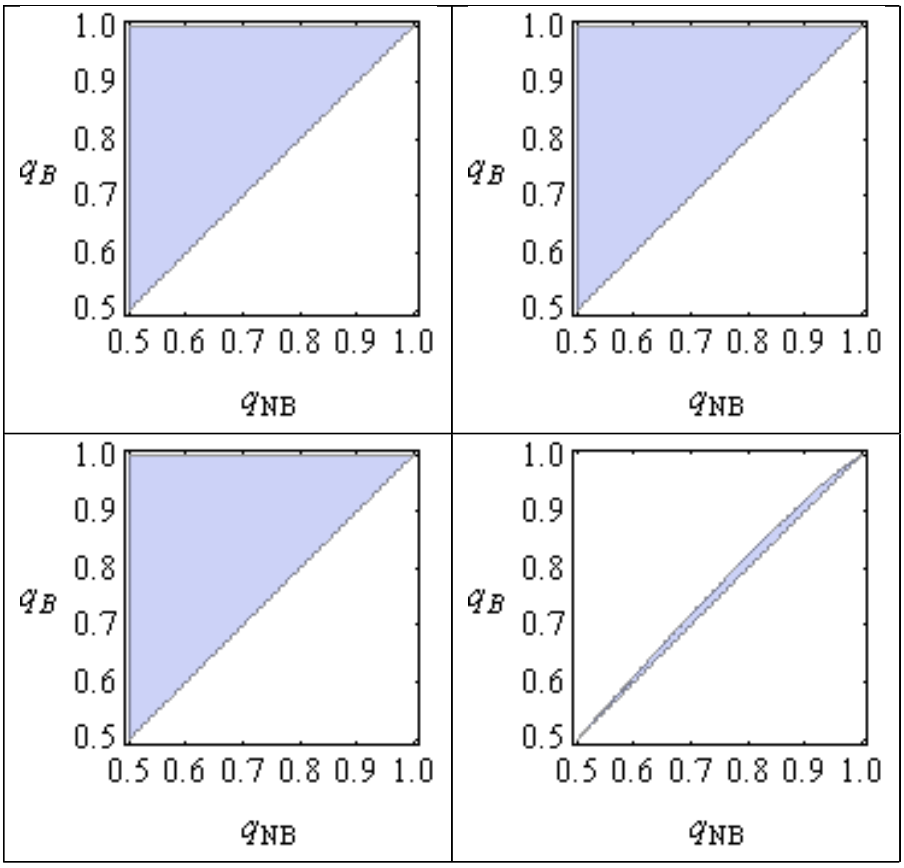

Figure 4A. The cheap-talk equilibrium (II)
($m = 3$ - left panel; and $m = 21$ - right panel)
($x = \frac{m+1}{2}$ - upper panel; and $x = m - 1$ - lower panel)

To complete the proof of the existence of the cheap-talk equilibrium as defined above, we need to show that voting in line with private signals in the pre-MPC meeting is sequentially rational for all Board members, given the belief that their proposal will not be automatically adopted in the MPC meeting. As we have explained above, the fact that MPC members will vote in line with their signals in the MPC meeting makes the Board members' votes in the pre-meeting immaterial for the MPC's outcome (however, these votes will provide information that will be used in determining members' voting strategies in the MPC meeting, as we have seen above). In general, for cheap talk to be informative, three conditions need to be satisfied (see e.g. Gibbons (1992)): (i) different sender types have different preferences over receivers' actions, (ii) receivers prefer different actions depending on senders' types, and (iii) receivers preferences over actions are not completely opposed to the senders'.[22] In our game, Board members are the senders of the common

[22]The cheap-talk game always has a babbling equilibrium, i.e. a babbling equilibrium where the Board members would not vote in line with their private signals in the pre-MPC

message (the policy proposal) to non-Board members; they are also senders and receivers of messages (votes) in the pre-MPC meeting; members' types are defined by their private signals. Clearly, the conditions for an informative cheap talk to arise are satisfied.

As a result we can conclude that the cheap-talk equilibrium constitutes a Perfect Bayesian equilibrium of our voting game, albeit in the small region where conditions (57), (58), (65) and (66) are simultaneously satisfied, i.e. where the shaded areas in figures 3A and 4A overlap. ■

Proposition 2. *The announcement of a prior policy proposal late in the MPC meeting, after non-Board MPC members have revealed their preferred policy options, allows for the informative voting equilibrium to arise for* $0.5 < q_{NB} < 1$, $0.5 < q_B < 1$ *and all committee sizes. It requires that the MPC agrees to adopt the prior proposal iff at least* $\frac{n+m+1}{2} - m$ *non-Board MPC members have independently expressed preference for the same policy option.*

Proof. Formally, the structure of the MPC game is now a little bit different than in Proposition 1: First, all MPC members individually observe their private independent signals about the state of the economy. Next, the pre-MPC meeting takes place. Then, the MPC meeting takes place: non-Board members 'cast' their votes and subsequently the Board's proposal is revealed. The MPC decision is the majority outcome. Finally, the state of the economy materializes and the payoffs are realized.

The proof is therefore partially equivalent to the proof of the existence of an informative equilibrium under Proposition 1. For Board members, rationality conditions and beliefs remain the same, hence the same results apply. The difference lies in the rationality conditions for non-Board members; specifically in the fact that they do not observe the Board's proposal before revealing their preferred policy options in the MPC meeting. Hence their individual beliefs regarding the informational content of the pivotality of their votes change.

We will now show that it is rational for any non-Board member i to vote in line with her private signal s_i iff the following conditions are met:

$$P_{i\in NB}(b|s_i = B, \text{pivotal}) \geq 0.5 \tag{67}$$

$$P_{i\in NB}(a|s_i = A, \text{pivotal}) \geq 0.5 \tag{68}$$

where $P_i(x|s_i = X$,pivotal) denotes the probability that the state of the economy is x, conditional on the private signal X, and the information deduced from the case(s) when her vote is pivotal for the MPC's outcome. The belief that all other non-Board members vote in line with their private signals while all Board members support the proposal, and the MPC will adopt the

meeting (e.g. randomly or in favor of one option regardless of their private signals). As a result their pre-MPC votes and the proposal will be rationally ignored by other MPC members when deriving their voting strategies in the MPC meeting. This in turn will justify the Board's voting strategies in the pre-MPC meeting. However, we will ignore this equilibrium here, as its outcome is equivalent to the situation when no prior policy proposal is made by the Board and it is analyzed in the main text.

proposal only if sufficient number of other MPC members have voted for the same option implies that her vote will be pivotal in two cases, when the Board has adopted proposal B and votes of other non-Board members' are split $\frac{n+m-1}{2} - m$ for option B and $\frac{n+m-1}{2}$ for option A or when the Board has adopted proposal A and votes of other non-Board members' are split $\frac{n+m-1}{2} - m$ for option A and $\frac{n+m-1}{2}$ for option B.

The above conditional probabilities are given as:

$$P_i(b|s_i = B, \text{pivotal}) = \frac{q_{NB}\widetilde{\widetilde{P}}_{NB}(\text{pivotal}|b)}{q_{NB}\widetilde{\widetilde{P}}_{NB}(\text{pivotal}|b)+(1-q_{NB})\widetilde{\widetilde{P}}_{NB}(\text{pivotal}|a)} \tag{69}$$

$$P_i(a|s_i = A, \text{pivotal}) = \frac{q_{NB}\widetilde{\widetilde{P}}_{NB}(\text{pivotal}|a, P=B)}{q_{NB}\widetilde{\widetilde{P}}_{NB}(\text{pivotal}|a)+(1-q_{NB})\widetilde{\widetilde{P}}_{NB}(\text{pivotal}|b)} \tag{70}$$

The informational content of the i's vote being pivotal under such conditions is given as:

$$\begin{aligned}\widetilde{\widetilde{P}}_{NB}(\text{pivotal}|b) = &\sum_{s=\frac{m+1}{2}}^{m} \binom{m}{s} q_B^s (1-q_B)^{m-s} q_{NB}^{\frac{n+m-1}{2}-m} (1-q_{NB})^{\frac{n+m-1}{2}} \\ &+ \sum_{s=\frac{m+1}{2}}^{m} \binom{m}{s} q_B^{m-s} (1-q_B)^{s} (1-q_{NB})^{\frac{n+m-1}{2}-m} q_{NB}^{\frac{n+m-1}{2}} \\ &= \widetilde{\widetilde{P}}_{NB}(\text{pivotal}|a)\end{aligned} \tag{71}$$

Hence the rationality conditions (67)-(68) can be simplified to one:

$$P_i(b|s_i = B, \text{pivotal}) = P_i(a|s_i = A, \text{pivotal}) = q_{NB} \geq 0.5 \tag{72}$$

We have shown that it is sequentially rational for any non-Board member i to vote in line with her private signal in the MPC meeting, if she believes that other non-Board members vote in line with their private signals and the Board's prior proposal will be adopted by the MPC if a sufficient number (that is, at least $\frac{n+m+1}{2} - m$) of non-Board members have expressed preference for the same option. This extends the existence of the informative equilibrium in our game to the whole region $0.5 < q_{NB} < 1$ and $0.5 < q_B < 1$ and all committee sizes. ■

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