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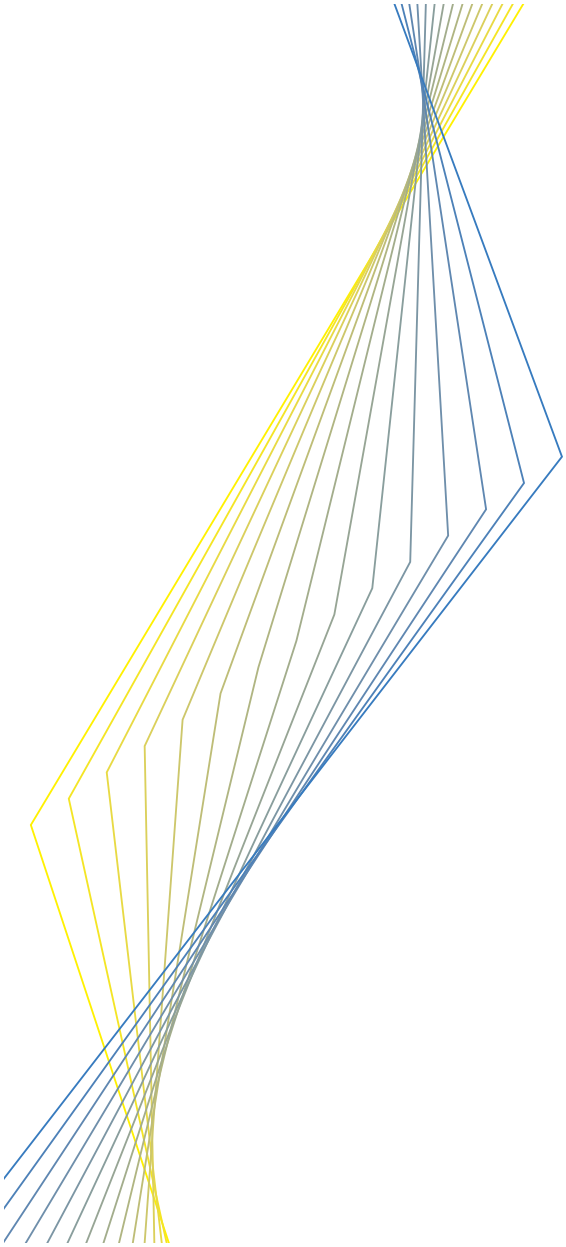

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INFORMATION ACQUISITION AND DECISION MAKING IN COMMITTEES: A SURVEY[1]

BY KERSTIN GERLING[2], HANS PETER GRÜNER[3], ALEXANDRA KIEL[4] AND ELISABETH SCHULTE[5]

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Contents

Abstract This is a survey on the recent game theoretic literature on committee decision making. We consider theoretical work on the role of (*i*) strategic voting, (*ii*) costly information acquisition, (*iii*) conflicting interests, and (*iv*) communication in committees. Moreover, we review recent experimental evidence on these issues. Our analysis focuses on the optimal size, composition, and decision rules of committees. We discuss implications for the design of monetary policy committees.

Keywords: committees, strategic voting, costly information acquisition, monetary policy committees.

JEL N.: D71, E52.

Non technical summary

This is a survey on the recent game theoretic literature on committee decision making. This literature has studied rational voter behavior when (*i*) committee members do not always reveal their signal about the true state of the world, (*ii*) committee members obtain their signal at positive costs, (*iii*) committee members may have different objectives and (*iv*) committee members may exchange views before voting. These insights are used to give advice on optimal committee design.

The main findings of this literature can be summarized as follows:

1. When information acquisition is costly, the optimal committee size is finite. Larger committees yield little incentives for individual information acquisition and may lead to less informed decisions. The optimal number of committee members is nonincreasing in information acquisition costs and ceteris paribus larger if (*i*) the costs of type I and type II errors are more similar, (*ii*) the prior is more diffuse and (*iii*) the signal is less accurate.

2. Even with conflicting interests delegation to one single member may be Pareto dominated by committee decision-making. When the committee rule is chosen appropriately, gains from sharing information outweigh distortions from information manipulation regardless of the extent of conflicts in the committee. The reason is that committee procedures are themselves chosen to control strategic misrepresentation given self-interested behavior.

3. The optimal committee size is always smaller than the first best level when there are conflicting interests. The reason is that noisy reports by committee members with policy biases are not as informative as if there were no incentives to distort information.

4. Committee decisions may improve if members of a committee have similar preferences. Increasing conflicts of interest lead to stronger incentives for strategic manipulation of private information.

5. Total social surplus may instead increase in preference heterogeneity when moral hazard problems in information gathering severely limit the feasible committee size.

6. The decision rule has to be adapted to the specific problem at hand. The majority rule has to be adjusted to the distribution of signals and the initial prior distribution of states of the world. Unanimity and the absence of communication lead to biased and undesired decisions in large committees. However, the introduction of pre-vote communication among committee members may alter these results. With pre-vote communication the voting rule becomes unimportant when committee members have identical objectives.

7. Imperfectly aggregating the available information may yield a higher overall expected utility level than perfectly aggregating the information. The reason is that imperfect aggregation induces more players to acquire information. The positive effect of this may dominate the negative effect of wasting some information.

8. Granting a committee independence may enhance the quality of its research. Incentives for information acquisition in the committee are higher if the committee can rely on the fact that policy is based on its opinion only. A dependent committee has little incentives to acquire information and is therefore less likely to acquire expertise.

1 Introduction

How do committees work? And how should they be designed? A recent game theoretic literature has added useful insights to the theory of committee decision making. The role of this paper is to provide an overview over the recent developments in this field and to relate it to some current debates on the design of committees for international decision making.

The formal study of committees is old. In his classical contribution Condorcet (1785) described a committee as a mechanism that efficiently aggregates decentralized information. In his famous jury theorem he argues that (i) increasing the number of informed committee members raises the probability that an appropriate decision is made and (ii) the probability of making the appropriate decision will converge to one as the number of committee members goes to infinity.

It is useful to relate the modern literature on committees to Condorcet's early insight. Condorcet's analysis was based on a simple set-up where (i) individuals always reveal their signal about the true state of the world, (ii) individuals obtain their signal at zero cost, (iii) all individuals have the same objective: to make a correct decision, and (iv) individuals do not exchange views before voting. In many cases of interest some (or even all) of these assumptions do not hold. Some voting rules may induce individuals not to vote in accordance with their own information. When information acquisition is costly, individuals provide less effort in large committees. Conflicting interests may lead to the misrepresentation of information. And communication may affect individual voting behavior when information is distributed asymmetrically. Recent papers have therefore addressed the issue of committee decision making when one or more of Condorcet's assumptions do not hold.

In this paper we first discuss contributions that study the role of strategic voting in committees (Section 2). Next we look at papers that analyze incentives for infor-

mation acquisition (Section 3). We then turn to the role of differences in preferences (Section 4) and after that to pre-vote communication (Section 5). Section 6 briefly discusses other theoretical issues. Section 7 summarizes some experimental results on committee decisions and relates them to the theoretical literature.

Key questions related to committee design are "How large should a committee be?", "Who should be in a committee?", "What is the optimal decision rule?", and "What should the delegating body do with the committee's decision?". We will summarize and compare the answers to these questions in Section 8. Finally, we analyze the consequences that one can draw for the design of monetary policy committees in Section 9.

2 Strategic voting versus naive voting

Unsatisfied with the statistical nature of prior proofs of the Condorcet Jury Theorem, a branch of literature investigates the features of strategic voting from a game theoretic point of view. In fact, relaxing Condorcet's first underlying assumption in a more realistic manner, in that individuals might not always reveal their signal about the true state of the world, leads to the break-down of his theorem. The reason is that with such strategic voting, a committee member tends to neglect his own information, while he tries to deduce other committee members' private information from their voting behavior. Then, he might either not vote any longer according to his own private information or even abstain, if he feels less informed and shares common values with the non-partisan part of the electorate. In unanimity regimes, it is strategic voting that causes the decision to be negatively biased away from the socially preferred decision, even if the size if the committee tends to infinity.

2.1 Sincere voting

Austen-Smith and Banks (1996) were among the first to unsheathe the implicit behavioral assumptions that individuals vote 'sincerely', i.e. as a member of a collective, each individual selects the alternative, he would have selected when voting alone, and 'informatively', i.e. each committee member's decision reflects the signal he received before.

The authors start from a simple Bayesian game. A finite set of individuals shares homogenous preferences for selecting the better, though in the presence of uncertainty about the true state of the world not definitely identifiable, better of two alternatives. The decision is taken by majority vote without abstentions. When making their decision, agents take into account a common prior probability in favor of one of the states of nature and a private signal that they received about the true state of the world. Austen-Smith and Banks show that it is the structure of individuals' information that endogenously generates heterogeneous policy preferences. Based on being pivotal, a rational voter is able to deduce other individuals' private signals and by incorporating this additional equilibrium information into his decision, he tends to neglect his own private information. It follows that sincere voting by all individuals cannot generally be both informative and rational. But then, it is no longer assured that majorities invariably do better than individuals in selecting the better of two alternatives. In fact, there is just one exceptional case: Only if the majority rule used is the optimal method of aggregating individuals' private information, the implicit and explicit assumptions of the Jury Theorem are satisfied. An aggregation rule is optimal, if and only if, the rule being used, it is rational for each member to vote informatively if all others do so.

In a second step, the authors allow for variations in the structure of individuals' information. Specifically, if the decision makers receive two independent private signals or additionally a public signal, the paper's main result applies again.

The authors conclude that the information environment crucially affects the outcome and that therefore, the appropriateness of the use of a majority rule hinges upon the characteristics of the encountered situation.

2.2 Abstention

In contrast to previous models of voter turnout, which traditionally focus on the costs and benefits of voting, Feddersen and Pesendorfer (1996, 1999b) present an informational explanation for the existence of abstention and roll-off.

Their model considers the behavior of a finite number of voters with heterogeneous preferences in a two-candidate (or two-alternative) election using plurality rule. There are three types of voters: two types of partisans, who, regardless of the state of the world, either prefer the status quo or the proposed alternative, and independents, who prefer to select the option that matches the true state of the world. After the state and the set of agents have been chosen, every agent receives private information about both his type and the probability with which one of the states of nature will be encountered. While some agents get a useless signal, others receive a perfect signal. These informed agents are certain about the realization of the state variable, which affects the utility of all voters.

Applying insights from the theory of auctions, the authors show that with private information and common values less informed voters have an incentive to abstain rather than to vote for either candidate even though voting is costless and though all abstainers strictly prefer voting for one candidate over voting for another. In fact, the uninformed independent voters' reason to cast a vote is to compensate for the partisans. That is how they maximize the probability that the informed voters decide the election. Having achieved this compensation, it is optimal to delegate the decision

via abstention to more informed voters. Coupé and Noury (2002) even provide some empirical support for this 'swing voter's curse'. An implication of Feddersen and Pesendorfer's findings is that differences in information about the different items on the ballot will make voters abstain on some issues and vote on others. Hence, the authors also provide an explanation for the existence of roll-off. Moreover, they go on to show that even though significant abstention occurs in large elections, the outcome of the election is almost always the same as with perfect information.[1]

2.3 Unanimity

With the minimization of criminal trials' expected wrongful verdict costs being a common social aim, unanimous jury verdicts were usually seen as a mean to reduce the probability of convicting an innocent while increasing the probability of acquitting a guilty defendant (see e.g. Klaven and Zeisel (1966) or Adler (1994)). Feddersen and Pesendorfer (1998, 1999a) were the first to challenge this basic intuition by taking into account strategic voting by jurors.

They construct a simple voting game. A jury with a finite number of members has to decide simultaneously and independently the fate of a defendant. Jurors are uncertain about the true state, but receive either of two possible signals, one indicating guilt and the other innocence. This signal is private and correct with a certain probability. A juror believing in the defendant's guilt with a probability higher than his threshold of reasonable doubt prefers the defendant to be sentenced.

Given any voting rule requiring a fixed fraction of votes to condemn, Feddersen and Pesendorfer are able to explicitly solve for the corresponding unique symmetric, responsive Bayesian equilibrium. Each juror behaves as if his vote was pivotal. Under

[1]Fey and Kim (2002) elaborate a correct proof of the first proposition, which does not require any alteration of the paper's results.

the unanimity rule, this is the case, if all other jurors agree, which reveals additional information about the true state. Such information may overwhelm the juror's private assessment of the case and cause him to vote with the others, though being inclined to vote contrarily. As a result and in opposition to the outcome under naive voting, even in a large jury, the probability of convicting an innocent defendant must stay bounded away from zero. The information aggregation potential of elections vanishes.

The authors also draw comparisons between the unanimity rule and a wide variety of special majority verdicts of a size less than unanimity, including simple majority rule. It turns out that among those voting rules, unanimous jury verdicts may be least appropriate to track the truth and result in higher probabilities of both kinds of error, i.e. convicting the innocent and acquitting the guilty. More precisely, a jury theorem holds for all voting rules other than unanimity. While with an increasing size of the jury, the probability of making a mistaken judgement goes to zero for all voting rules, except for unanimity, even the opposite may be the case for unanimity: the probability of convicting an innocent defendant may even increase with the size of the jury. Based on an example confronting different voting rules for a fixed jury size, the authors finally conclude that in order to reduce the probability of convicting an innocent defendant, any other supermajority rule with a large jury is more appropriate than unanimity.[2]

[2]However, the authors admit that the degree to which strategic voting and private information matter in actual juries is crucial for the ultimate outcome and thus at last emerges to be an empirical question. Beyond that, Coughlan (2000) substantially undermines Feddersen and Pesendorfer's findings by extending their basic setting to include more realistic features of actual jury trials that save the unanimity rule in jury decisions. In particular, if a jury faces the risk of a mistrial, i.e. that no unanimous decision can be reached, or if there is deliberation, i.e. that jury members communicate their private information before the decision is made, unanimity voting outperforms majority voting.

3 Incentives for information acquisition

The analysis of strategic voting points out that committees need not yield better results than individuals. However, this result is based upon fixed decision rules which may no longer be appropriate in larger committees. If decision rules are adjusted properly, then, the Condorcet Jury theorem still holds. Reasons for limits on committee size can be found if one drops the rather harsh assumption that information comes for free in order to study incentives for information acquisition in committee decision making. Obviously, costly information acquisition in a committee constitutes a public good - it tends to be underprovided. Increasing the number of committee members reduces incentives for information acquisition. The formal analysis of these incentives yields different results. Papers in which information acquisition is a discrete choice come to the conclusion that larger committees may yield poorer decisions and a lower social surplus. On the other hand, when information acquisition is continuous, larger committees may still yield better informed decision making in the aggregate despite lower incentives for information acquisition. After considering the case for large and small committees and the conditions under which the optimal outcome can be reinstalled, we turn to information acquisition incentives that arise from the relation between the committee and a parent body with limited authorization to revise the committee's decision.

3.1 Large committees

Martinelli (2002) shows that a large committee may anticipate the right state of the world with probability close to one, although the committee members do not know anything about the state of the world ex ante and information acquisition is costly. This is true if the information cost function satisfies certain conditions. The paper's main point is that "rational ignorance" on the part of committee members

is consistent with a well-informed committee in the sense of forecasting the correct state of the world with a high probability.

However, he uses a quite restrictive framework to come to this conclusion: There are voters who have to decide on two alternatives A and B, with A being the better one in state of the world A and B being the better one in state of the world B. Both states are equally likely ex ante and implementing A (B) in state A is worth as much as implementing B (A) in state B. Moreover, there are "extremists" among the voters, who, regardless of the state, either prefer A or B . The ex ante probability of being a type A extremist is equal to being one of type B. Agents may invest in information, thereby receiving a signal whose accuracy linearly depends on the information investment. That is to say that if a voter invests x in information, he receives a signal which is correct with probability $1/2+x$. The information investment costs follow a strictly convex, twice differentiable function.

The timing is as follows: Firstly, nature selects the voter's type which is his private information. Secondly, voters decide simultaneously and unobservably the quality of information. Then, voters can either vote for A or B. Majority wins.

Extremists never acquire information and always vote for their preferred alternative. Because of the symmetric structure, there is no problem with insincere voting among the moderate voters under majority rule (see Austin-Smith and Banks, 1996).

If marginal information cost at zero information is positive and the number of voters is large enough, there exists no equilibrium with information acquisition. If marginal cost is zero at the point of zero information, there exists a unique equilibrium in which all moderate voters acquire the same amount of information, in turn depending on its marginal benefit, and in which they vote sincerely.

If the second derivative of the information cost function is also zero at the point of zero information, the probability of choosing the right decision (in the sense that alternative X is chosen if the state of the world is X) converges to one as the number

of voters goes to infinity. If it is positive, but bounded, the probability of choosing the right alternative converges to some value between 1/2 and 1, depending on the parameters. If the value of the second derivative converges to infinity as information converges to zero, success probability converges to 1/2 as the number of voters goes to infinity. Moreover, elections become very close as the electorate grows.

The intuition for these results is the following: If information is cheap enough (first and second derivative being zero at zero information), moderate voters will acquire some, because they are pivotal with positive probability. The existence of extremists and the imposed symmetry ensure that the probability of being pivotal does not fall too fast as the number of voters grows. Although information acquisition of the individual moderate voter goes to zero as the number of voters goes to infinity, it does so slowly enough, to allow for the effect of large numbers to kick in. The poor information of the individual voter does also explain why elections are close in this set-up. Moreover, this feeds back on information acquisition incentives, since in close elections the probability of being pivotal is high.

3.2 The case for small committees

In contrast to Martinelli (2002), Mukhopadhaya (1999), Nitzan (2001) and Persico (2000) show that - due to a free rider problem in information acquisition - a larger jury may make worse decisions.

A nice and intuitive example is Mukhopadhaya's (1999) two player game with a perfect signal. Each player may purchase a perfect signal about the state of the world. Both players share information. The game has two asymmetric pure strategies Nash equilibria where one of the two jury members acquires the perfect signal. The other is a mixed strategies equilibrium in which both players buy the signal with a positive probability. In the case with one single decision maker, the decision maker always

decides to buy the signal. Hence, in the mixed strategies equilibrium the probability of making a correct decision is lower than in the one decision maker case.

Mukhopadhaya's game with an imperfect signal goes as follows: First nature chooses the true state of the world. Then each agent may decide to invest in the costly signal. Next, all the jurors pool their information which is possible because they have a common objective. In the vote they all agree on the decision that has to be taken.

The game has a symmetric mixed strategies equilibrium. The author shows that for extreme (high) values of the signal's precision, one juror is more likely to reach a correct decision than three jurors. The author provides an example where the probability of making a correct decision is first increasing and then monotonously decreasing in the number of jurors.

In a similar setting, Persico (2000) determines the optimal voting mechanism consisting of the voting rule and the committee size. A voting mechanism has to aggregate information efficiently as well as to provide proper incentives to acquire information.

The underlying questions are: Under what circumstances should majority determine collective decisions, when is it better to rely on more stringent measures of consensus? And how large should a group of decision makers be?

Persico designs the optimal voting mechanism by choosing the number of committee members n and the plurality rule R needed to change the status quo. The optimal mechanism maximizes agents' expected utility from the collective decision. Costs enter only insofar that a smaller committee is chosen only if this does not decrease expected utility. To solve the induced game, Persico restricts attention to pure and monotone strategies equilibria of the induced game – more precisely, he is only interested in the most efficient equilibrium in pure and monotone strategies. Voters are homogenous and can aggregate information only through their votes, communication is considered to be impossible.

Plurality is determined à la Austen-Smith and Banks (1996), i.e. R is chosen such that the maximum number of agents vote informatively in equilibrium. The basic trade-off is that by enlarging the committee (combined with an adjustment of the voting rule R), the decision becomes more accurate, but voters become less pivotal such that their information acquisition incentive shrinks. If the committee is too large, no one will acquire information since the probability of deciding the final outcome is too low. Thus, there exists a bound on n.

There exists a bound on R, too: The optimal fraction of votes needed to change the status quo R/n can never be greater than approximately the accuracy of the signal. This is true irrespective of agents' preferences, i.e. how much they care about first and second order mistakes. This implies that large pluralities (in the extreme unanimity) are optimal only if the information available to committee members is sufficiently accurate.

As n grows, the optimal decision rule R converges to simple majority. The optimal number of committee members is nonincreasing in information acquisition cost and ceteris paribus larger if (i) the costs of type I and type II errors are more similar, (ii) the prior is more diffuse and (iii) the signal is less accurate.

The above statement, that an increase in committee size decreases the incentives to acquire information, is only one part of the story. The opposite is true as long as the optimal plurality rule R/n converges to signal accuracy: Because the optimal decision rule R itself moves with n (and at half speed of the growth of n, as Persico shows), it creates an opposite-directed effect and an increase in n associated with a minor increase in R makes the individual voter in fact more pivotal than in the smaller committee, as long as R/n has not yet reached approximately signal quality. As R/n converges beyond signal quality to simple majority, both effects operate in the same direction and information acquisition incentives indeed decrease with further increases in committee size.

Persico shows that his results also hold for heterogeneous agents by considering two possible types. If agents' types are observable and preferences sufficiently diverging, it is optimal to leave the decision to a group of only one type, using the optimal rule that would be used if these agents were the only ones the mechanism designer is interested in. There exists no voting rule that incorporates votes of both types such that all types vote sincerely. If agents' types are unobservable but the number of agents of each type is common knowledge, again the decision rule of only one group is used, modified in a way such that the votes of the other type are "sterilized", i.e. in equilibrium the other type votes in order to correct the voting rule regardless of their signal and the type whose decision rule is used votes sincerely.

The author admits that the restriction to pure strategies may be critical, since allowing some agents playing mixed strategies might indeed lead to superior outcomes, because pure strategy players get stronger incentives to acquire information. Moreover, the role of communication is entirely neglected.

3.3 Relation to the delegating authority

Incentives to acquire information do also depend upon the relation between the committee and the delegating authority. Gilligan and Krehbeil (1987) argue that restrictions on the ability of the parent body to amend committee proposals may enhance the informational role of committees. The model of Gilligan and Krehbeil (1987) works as follows. There are two players, the floor and the committee. A policy x has to be chosen, x is a real number. The desired policy of the floor is zero, the desired policy of the committee is larger than zero, however the desired policy of both actors is affected in the same way by a shock. The committee members may acquire costly information about this shock. The committee reports a bill, after this report the floor

makes a decision. Under the unrestricted procedure the floor may pick any policy after obtaining their report, under the restricted policy it may either accept the bill or stick to the status quo. Gilligan and Krehbeil show that restrictions on the ability of the parent body to amend committee proposals may provide the committee with better incentives to acquire information and may lead to an outcome which is better both for the parent body and the committee.

4 Conflicting interests

Even if one agrees on the validity of the Condorcet theorem's crucial assumption in a narrow sense, that making a correct decision is all committee members' common objective, there is still room for violation if one adopts a broader view and allows voters to differ in their preferences. Very different approaches have recently been developed to study the non-neglectable role of conflicting interests in committees. In some jury models jurors care differently about wrongful acceptance and wrongful rejection of a hypothesis. Other models focus on the degree of conflicts affecting the incentives to exaggerate reports about the own private information and hence the efficiency of committee's decision. Finally, we consider the case of interdependent member preferences.

4.1 Caring differently about mistakes

Gerardi (2000) develops a model of collective decision making where individuals with heterogeneous preferences (which are private information) have to aggregate private signals in order to make an informed decision. He shows that any nonunanimous decision rule is asymptotically efficient. In large committees, the unanimous rule almost never leads to the decision for which unanimity is required.

The author introduces a set-up using an example the reader should already be familiar with from section 2.3: A jury has to decide whether to convict or acquit a defendant who might be innocent or guilty. Jurors prefer to acquit the innocent and to convict the guilty. In contrast to the set-up in 2.3, they care differently about convicting the innocent and acquitting the guilty. Ex ante, they have no information about the guilt or innocence of the defendant, but they receive a private signal which is correct with probability p. Jurors vote strategically, i.e. they condition their vote on the event of being pivotal, taking into account other agents' strategies. They are not allowed to communicate before voting.

Timing is as follows: Nature draws the agents' types according to a commonly known distribution. Agents learn their private signal and vote. In order to solve the game, the author restricts attention to symmetric Bayesian Nash equilibria in which players do not use weakly dominated strategies.

There exists no voting rule under which all jurors vote informatively in equilibrium. Instead, jurors use cutoff strategies: Up to a certain threshold, which depends on the encountered type, a juror always votes to convict, up to the next threshold, he votes informatively and beyond, he always votes to acquit the defendant.

The intuition is the following: "low" types are very concerned about acquitting the guilty. The information they can infer out of their signal and the event of being pivotal does not convince them of the defendant's innocence, so they vote to convict him. The same argument holds for "high" types. They are so concerned about convicting the innocent, that equilibrium information does not convince them of the defendant's guilt. Medium types are convinced by their signal and use it for their decision.

A symmetric Bayesian Nash equilibrium exists for any decision rule and any jury size. Under unanimity, the probability that an innocent is convicted converges to zero as the jury size grows to infinity, but the probability to acquit the guilty converges

to one. Thus, protecting the innocent comes at the prize of acquitting the guilty. Moreover, the probability of a convicted defendant being innocent converges to zero. Under any nonunanimous rule, which is defined as a fraction of voters required to convict the defendant, the probability to convict the innocent as well as the probability to acquit the guilty converge to zero.

The author does not develop an optimal voting mechanism, his main points are that unanimity is not optimal in large juries, whereas nonunanimous rules are asymptotically efficient. The first result is not that surprising, since the existence of a single voter with sufficiently extreme preferences suffices to free the guilty. As the jury size converges to infinity, the existence of such a voter will be very likely, even though evidence of guilt, on its part inferred out of being pivotal, becomes stronger.

On the other hand, nonunanimous rules, characterized by a fraction of votes required to convict the defendant, have different asymptotic properties. Take any supermajority rule. As the jury size becomes larger, the number of "acquit-votes" needed to acquit the defendant grows and, at the same time, the interval of types always voting to acquit shrinks, since the evidence of the defendant's guilt becomes stronger. So, the asymptotic efficiency of the nonunanimous rule is not surprising either.

To sum up, Gerardi's results strengthen the findings of Feddersen and Pesendorfer (1998, 1999a) about the inefficiency of unanimity.

4.2 Binary decisions and continuous information

Li, Rosen, and Suen (2001) analyze small-committee decisions when members have partially conflicting interests and possess private information. Private information is a continuous variable and conflicting interests concern first and second order mistakes. Preferences are common knowledge. Their main result is that information cannot be fully shared and voting procedures arise as the equilibrium method of information aggregation.

A committee must choose between two alternatives. Each member receives a private observation (a real number). Since information is private, committee decisions are made on the basis of members' reports of their private data. The authors show that under these circumstances, information cannot be fully shared among committee members in the sense that it is not possible to exactly conclude from reports on private signals. Efficient (or full) sharing requires that the committee decision responds to small changes in any members' data. This property fails in any Bayesian equilibrium of any decision-making procedure. Incentive compatibility implies that continuous data observed by each member are partitioned and transformed into rank order categories. In equilibrium, personal thresholds are chosen to undo the presumed biases of other committee members, but not by enough to completely nullify the information of the others. The coarsening of information balances incentives to exaggerate information and incentives to share information. Nevertheless, incentives for manipulation and countermanipulation generate a larger area of disagreement among committee members than is implied by their inherent conflicts in preferences.

It is shown that the greater the latent consensus among members, the greater are the opportunities for presenting private data in finer categories. On the other hand, conflicting interests among committee members impose an upper bound on how fine information partitions can be. Indeed, the quality of committee decisions improves with the degree of consensus.

The authors demonstrate that delegation to one single member is Pareto dominated by committee decision-making. When the committee rule is chosen appropriately, gains from sharing information outweigh distortions from information manipulation regardless of the extent of conflicts in the committee. The reason is that committee members are more cautious in casting the decisive vote as if they were to make the decision alone in order to take advantage of the other members' data.

Moreover, if one member is known to have data of higher quality, the others cast their decisive votes less frequently.

The coarsening of information implies that the committee decision rule is ex post inefficient - but that's the best we can get.

4.3 Committee size with conflicting preferences

Feddersen and Pesendorfer (1997) analyze the performance of elections with heterogeneous voters when there is uncertainty about a one-dimensional state variable. Despite heterogeneity and a vanishing fraction of informatively voting agents, elections perform well. The authors show that the information environment is crucial in determining the effectiveness of elections as information aggregation mechanisms.

There is a two-candidate election in which a population of voters has, costlessly and by a given majority rule q, to decide between an incumbent and a challenger. The challenger wins if he receives a fraction q of votes. Each voter's payoff depends on his specific preference type, the true state of nature that is common to all voters and the winning alternative. Preference types are drawn independently from a commonly known distribution. Each voter knows his own preference type but does not know the other voters' types. Every voter receives a private signal that is correlated with the true state of nature.

Thus, in taking a decision, two things matter: the information a voter can infer about the state of nature, and his preferences. In equilibrium, preference types can be divided into three groups: those who always vote for either alternative and those who take informative action, i.e. who make their vote depending on their private signal.

As the size of the electorate goes to infinity, the fraction of players who condition their votes on their private information goes to zero. Nevertheless, voting fully ag-

gregates information in the sense that with probability close to one the alternative is elected that would have been chosen if all private information was common knowledge (the q-median's preferred outcome). Moreover, with probability close to one, in equilibrium a candidate receives a fraction of votes close to the fraction necessary to win the election.

The intuition for the results is the following: Voters condition their voting strategy on the event of being pivotal. This implies that beliefs about the state of nature concentrate on the state in which, given the equilibrium strategy profile, it is most likely that the challenger receives a fraction of votes q. As the voting population grows to infinity, this evidence becomes very strong and the fraction of voters who still use their signal to update their beliefs goes to zero. Voters behave as if they for sure were in the predicted state. Although the fraction of voters taking informative action goes to zero, the number of them goes to infinity. Since these are the voters who determine the outcome of the election, the election performs very well.

However, if besides the uncertainty about the state variable, there is another source of uncertainty, e.g. concerning the distribution of preferences, or if the payoff relevant uncertainty is of higher dimension, an election will generally not satisfy full information equivalence and the fraction of voters who take informative action does not converge to zero. The reason is that the beliefs about the state of nature conditional on being pivotal do not converge to a degenerate distribution. In the light of the importance of the dimensionality of uncertainty for the performance of elections, the authors encourage a profound analysis of the events preceding elections, such as nominating procedures, campaigns and polls.

Taking costly information acquisition into account, Cai (2001) develops a model of committee size when agents are uncertain (i) about the state of the world (which is a point on the real line) on which the outcome of a continuous policy decision depends and (ii) about their own policy preferences. When exerting nonverifiable effort, an

agent learns his policy preference and receives a noisy signal about the state of the world. Thus, conflicting interests among committee members arise from information acquisition in this model.

N agents are selected into a committee by a principal who represents society's preferences in the sense that his policy preference coincides with an uninformed agent's expected preference. The committee members' task is to acquire information and to report it to the principal who uses it to update his beliefs about the state of the world and then decides upon the policy variable. Updated beliefs and incentive compatibility conditions for committee members constitute the elements for a Perfect Bayesian Nash Equilibrium of this multiple stage incomplete information game for a given committee size N.

Information acquisition is costly and unobservable. Since information is soft and informed committee members know their policy preference which may differ from the principal's, there exist incentives for strategic information manipulation.

The game is solved by backward induction.

First, the author characterizes a reporting equilibrium of the information aggregation stage. Attention is restricted to strictly monotonic (reversible) reporting strategies. In this equilibrium, committee members convey all their information (except their policy preferences) to the principal. Committee members with no policy biases report truthfully, and those with policy biases exaggerate by a multiple of their policy preference. Uninformed committee members prefer not to submit any information at all, because their expected policy preference coincides with the principal's and a signal announcement would only create additional noise.

The principal makes his decision as the (to exaggeration adjusted) mean of all reports. The author shows that this equilibrium is essentially the unique equilibrium consisting of reversible reporting strategies, essentially unique in the sense that all fully reversible equilibria have identical outcomes. Moreover, he proves that it is the

most efficient among all equilibria. Given this reporting equilibrium, the committee members' incentives to gather information and the optimal committee size are studied.

Information acquisition incentives limit the size of the committee. The optimal number of committee members is lower than the first best, i.e. if no incentive problems would exist and any expected gain from additional information is traded off against participation costs. Heterogeneity of preferences plays the crucial role: If preferences were identical among all agents and information acquisition costs did not exceed participation costs, the first best would be attainable since interests would be completely aligned.

Interestingly, information acquisition incentives and therewith committee size may increase in preference heterogeneity. Benefits from information acquisition contain two elements: firstly, the policy becomes more informative and secondly, the agent learns his policy preference and gets the chance to manipulate the policy in his own favor. Information acquisition serves as an insurance against preference uncertainty. When information acquisition costs are high, such that the committee size is limited by members' shirking tendency, an increase in preference heterogeneity raises the value of that insurance and mitigates the shirking problem.

4.4 Decision rules with interdependent preferences

Grüner and Kiel (2003) analyze collective decision problems in which individual bliss points are correlated but not identical. The authors compare the performance of two specific decision mechanisms as regards different degrees of correlation.

In order to take a common decision, all agents obtain private information about their most desired policy, but the individually preferred decision of a group member does not only depend on his own private information but also on the other group members' private information. Decision problems are characterized by a parameter

which measures the extent to which private information affects all individuals. This specification includes the private values case for the lower bound of the interdependency parameter and the common values case for its upper bound.

Participation in the decision is not voluntary and monetary transfers are excluded a priori. Instead, the mechanisms map individual announcements of the private information into the collective decision. Attention is restricted to two specific decision mechanisms, the median and the mean mechanism. The main difference between these two mechanisms is how they deal with the announcements of private information. Under the median mechanism changes in extreme positions are disregarded, since the median alone determines the final decision. On the contrary, the nature of the mean mechanism is to take all available information into account. Therefore, under the mean mechanism extreme positions influence the decision.

The main result of this paper is the identification of two symmetric Bayesian Nash equilibria of the respective games. The performance of the mechanisms depends upon the extent to which spillover effects affect the economy. With weak interdependencies, the median mechanism dominates the mean mechanism, whereas with strong interdependencies it is optimal to use the average as decision mechanism.

If individual preferences are strongly correlated, then making all agents participate in the decision is better than restricting entry into the decision process. If there is only a small common component then it is better to use the median mechanism. The intuition is that for weak interdependencies the equilibrium strategy under the median mechanism implies announcement behavior close to truth-telling whereas the equilibrium strategy under the mean mechanism leads to strong exaggeration of private information. Therefore, average taking is outperformed by ignoring some of the information available. Since the degree to which interdependencies influence untruthful announcement behavior is stronger under the mean mechanism, this intuition holds for a wide range of interdependencies, only for very high degrees it is reversed.

There are three main points that remain unconsidered in this paper. First, the authors abstract from individual rationality considerations. However, if participation constraints are taken into account, even individuals not participating in the mechanism would be affected by the common decision due to interdependent valuations. This would imply endogenizing the participation constraint. Secondly, in a setting with interdependencies there may be scope for pre-vote communication. The question is if an improvement upon the equilibria of the original game is possible when people are allowed to communicate before they have to vote. It is well known that equilibrium behavior can be affected if agents have the opportunity to exchange information prior to playing some game. Finally, another question is the design of an optimal mechanism for the class of collective decision problems studied. This would mean to find a mechanism that implements the welfare maximizing decision for all degrees of spillovers, not only for the maximum amount.

5 Communication

The models that we have discussed so far rely upon Condorcet's original assumption that individuals in a committee do not communicate before they cast their votes. Some people might argue that this whole branch of literature bears useless results when extensive discussion and exchange of information precedes the votes, hence reducing incentives for strategic voting à la Austen-Smith and Banks (1996). Recent theoretical work indeed proves that pre-vote communication gives rise to a new kind of equilibrium, since first-stage mutual pre-vote revelation of impressions about the true state of the world replaces the need for committee members to augment private information by deducing other members' information from their voting behavior. Then, in a second stage, i.e. the voting stage, all voters agree on the preferred alternative: the one that matches the state of the world with highest probability given the signal vec-

tor. This voting behavior in the second stage is obviously an equilibrium. Moreover, given the second stage voting behavior and given truthful revelation, it is optimal to reveal the own information truthfully in the first stage.

One might be tempted to argue that - because in reality communication actually takes place in committees - the so far surveyed branch of literature is completely useless. From our point of view, this reflects an often too idealistic perception of reality. As we shall see, strategic voting plays a role when committee members have private information about their preferences - even if communication takes place prior to voting (Doraszelski et al. (2002)) . This crucially highlights the necessity to explicitly model the various temptations that committee members might be exposed to and their respective effects on the final voting outcome. Hence, the previously reviewed literature at least helps to enhance peoples' sensibleness.

In this section, we review the (small) literature on pre-vote communication in collective decision making, resulting in significant alterations of the results of previously discussed committee voting models. After having presented how Gerardi and Yariv (2002) derive the irrelevance of voting rules for the equilibrium outcome ensued from pre-vote communication and costless information, we further follow them to demonstrate the need for a limited optimal committee size when information becomes costly. Moreover, Doraszelski et al. (2002) show that pre-vote exchange of views improves the decision in the presence of conflicting interests.

5.1 Irrelevance of voting rules

Gerardi and Yariv (2002) consider a voting game where committee members may communicate before they cast their votes. The paper contains two models. In the first model, the role of communication is studied in a set-up where individuals obtain their information without investing effort. In the first stage, each individual obtains a

signal which is his private information. His utility is a function of the collective action - which may take two values - and of the vector of signals. In the second stage, the cheap talk stage, individuals may communicate. In the third stage, individuals cast their votes. The voting rule maps the vector of votes into the set of outcomes. The voting rule is characterized by the number of votes required to implement a certain decision. The main result of the first part of this paper is that with cheap talk, the set of equilibrium outcomes is independent of the voting rule. As we have seen above, this is not the case in models without cheap talk.

5.2 Imperfect aggregation and incentives

In the second model, Gerardi and Yariv (2002) consider a game of costly information acquisition. There is a true state of the world which may take two values. Individuals share the common objective that the decision should be the appropriate one for the given state of the world. Each individual may purchase a signal which is correlated with the true state of the world. Again, the model has three stages. In the first stage, the designer chooses an extended mechanism which consists of the size of the committee, the voting rule and the rule that specifies how the players can exchange messages before voting. In the second stage, the agents observe the mechanism and decide whether to purchase the signal. These choices are made simultaneously. In the third stage, members of the committee communicate according to the prespecified rules and vote.

The main results are the following ones: First, the authors show that the optimal committee is of bounded size - as before. Second, they show that imperfectly aggregating the available information may yield a higher overall expected utility level than perfectly aggregating the information. The reason is that imperfect aggregation induces more players to acquire information. The positive incentive effect may dominate the negative effect of wasting some information.

5.3 Communication and conflicting interests

Doraszelski et al. (2002) also analyze a voting game which includes a communication stage prior to voting. They consider a two person committee which has to decide whether to change the status quo or not. The status quo is optimal in one state of the world, changing it in the other one. Agents care differently about first and second order mistakes - hence there are conflicting interests in the committee. These preferences are the agents' private information.

The game proceeds as follows: Nature draws the agents' types independently according, to a commonly known distribution. Agents receive a signal which is correlated with the true state. In the "one sender" version of the game, one of the agents sends a message to the other one, in the two sender game both agents send messages to each other. Both agents vote simultaneously and the collective decision is implemented. The status quo is maintained unless both vote in favor of changing it.

The authors look for Perfect Bayesian Equilibria with the additional requirement that agents do not use weakly dominated strategies. In order to explore the interaction of communication and voting, they restrict attention to responsive robust cutoff equilibria, i.e. equilibrium strategies that imply that the receiver and the sender condition their votes on their types, their signals and the sender's message. The authors provide a complete characterization of these equilibria and show that communication is beneficial. Communication's main purpose is to serve as a "double-check": If a player's information conflicts with his preferences, he uses the submitted information of the other player to confirm his own.

In the "one sender" game in which agents possess information of different quality, the identity of the sender is irrelevant: The game in which the better-informed agent

is the sender is outcome-equivalent to the game in which he is the receiver. After observing the signal the better-informed sender conditions the message decision on an event that has the same probability as the event on which the better-informed receiver conditions the voting decision after observing the message and the signal. The authors conclude that communication and voting are perfect substitutes in the sense that information not transmitted in the communication phase will be aggregated in the voting stage.

The authors compute ex ante utilities for the pure voting game, the one sender and the two sender game for a uniform type distribution. Agents' ex ante utility is larger with two senders than with one sender. And it is larger with one sender than with no sender. However, this is due to decreasing returns to scale.

Since adding communication complicates the analysis considerably, the authors concentrate on a framework with two players, two states and two signals. So, there is scope for future research to generalize this set-up. For example, adding players would allow to compare different voting rules.

6 Decision skills

It is not surprising, that the distribution and quality of decision skills also matter for committee voting. Two papers that have dealt with different decision skills are Nitzan and Paroush (1982) and Karotkin and Nitzan (1995). Nitzan and Paroush (1982) show that with different decision skills the optimal decision rule is a voting rule that grants more weight to better qualified decision makers. However, one should expect that pre-vote communication makes weighting unnecessary in some cases. Karotkin and Nitzan (1995) show that a more egalitarian distribution of decision skills may justify a reduction of the number of individuals who participate actively in a decision.

7 Experimental results

Experimental work seeks to elucidate the generality of various theoretical results. Guarnaschelli, McKelvey and Palfrey (2000) provide a first experimental study of jury decision making. The experimental set-up is identical to the one described in models of voting under imperfect information such as the ones by Austen-Smith and Banks (1996) or Feddersen and Pesendorfer (1998, 1999a). Individuals were informed about the existence of a true state of nature and they were given a signal with known stochastic properties. This set-up is used to test for the presence of strategic voting. It turns out that individuals indeed vote strategically.

In addition, the authors conducted a so-called straw poll experiment. In this experiment, individuals were asked for the simultaneous announcement of a signal after which the vote takes place. There is an equilibrium of this game where all individuals announce their signal correctly in the first round and then place identical votes in the second round. It turned out that over 90 % of the individuals revealed their signal in the first round. In the second round, about 84 % or more voters voted in a way consistent with the outcome of the first round. Voting with a straw poll improves results in one respect: The probability of one type of error was reduced while the other was not affected.

There are other results in the paper by Guarnaschelli et al. which are at odds with theoretical predictions. For example, inconsistent with the theoretical findings of Feddersen and Pesendorfer (1999a), in an experiment with unanimity rule, the probability of convicting an innocent defendant declines with jury size.

The authors also find that voting behavior might be consistent with jury members playing a mixed strategies equilibrium. Actually, the Austen-Smith and Banks (1996) game has mixed strategies equilibria: Whereas some individuals vote sincerely, others always vote to convict and others mix. It should be noted that in this experiment

payoffs from correct predictions and from type I and type II errors are the same for all individuals. Individuals received 50 US cents if the group decision was correct and five cents if it was incorrect.

Blinder and Morgan (2000) present experimental research on the quality of group decision making. The set-up of their basic experiment is the following: Individuals (or groups of individuals) are confronted with the result of a binary lottery. The lottery has an initial probability of 50 % for both possible states. The individuals were told that the probabilities would change at some randomly selected point of time during the experiment. The change would either go up to 70 % or down to 30 % for each of the events. The individuals were asked for a guess of the point of time when the random process was changed. They were punished for a decision that has been made too late and they received a reward for a decision that was correct.

Group members were presented exactly the same information as an individual decision maker: the outcome of the random draw. The first hypothesis that has been tested was that groups make decisions more slowly than single individuals. However, the hypothesis that the decision takes as much time in a group as individual decision making could not be rejected. The hypothesis that groups outperform individuals was instead strongly supported by the experimental data. The third hypothesis concerned the speed of group decisions with different decision rules. The authors compared majority and unanimity rule. It turned out that unanimity rule worked faster than majority rule. Moreover, under majority rule individuals tended to reach unanimous agreements.

The experimental results by Blinder and Morgan are very useful because they show that a group may indeed perform better than individuals in analyzing the same information set (the series of random draws). The fact that decisions do not seem to take more time when a group decides under unanimity rule is somewhat surprising. Further theoretical and experimental research on the issue of timing might help to clarify this issue.

8 Summary of theoretical results

Actually, it is needless to say that the applicability of the theoretical results to the real world depends on the specific features of an encountered situation. As one will realistically expect to face e.g. a combination of the Condorcet Jury Theorem's underlying assumptions to be violated to various degrees or further complications, the results derived in this literature can only serve as a rough, but sound guideline.

Nevertheless, the review of this literature allows drawing some general conclusions on the optimal organization of committees. These insights will guide our discussion of actual committee decision making concerning the optimal size, composition, decision rule, and the special implications for MPCs. Figure 1 illustrates the main results concerning the most important features of committees: decision rule and committee size. We include results for unanimity in this illustration, because this is a decision rule of special interest for real-life decision making (e.g. in jury trials) and has therefore gained special interest in theory as well.

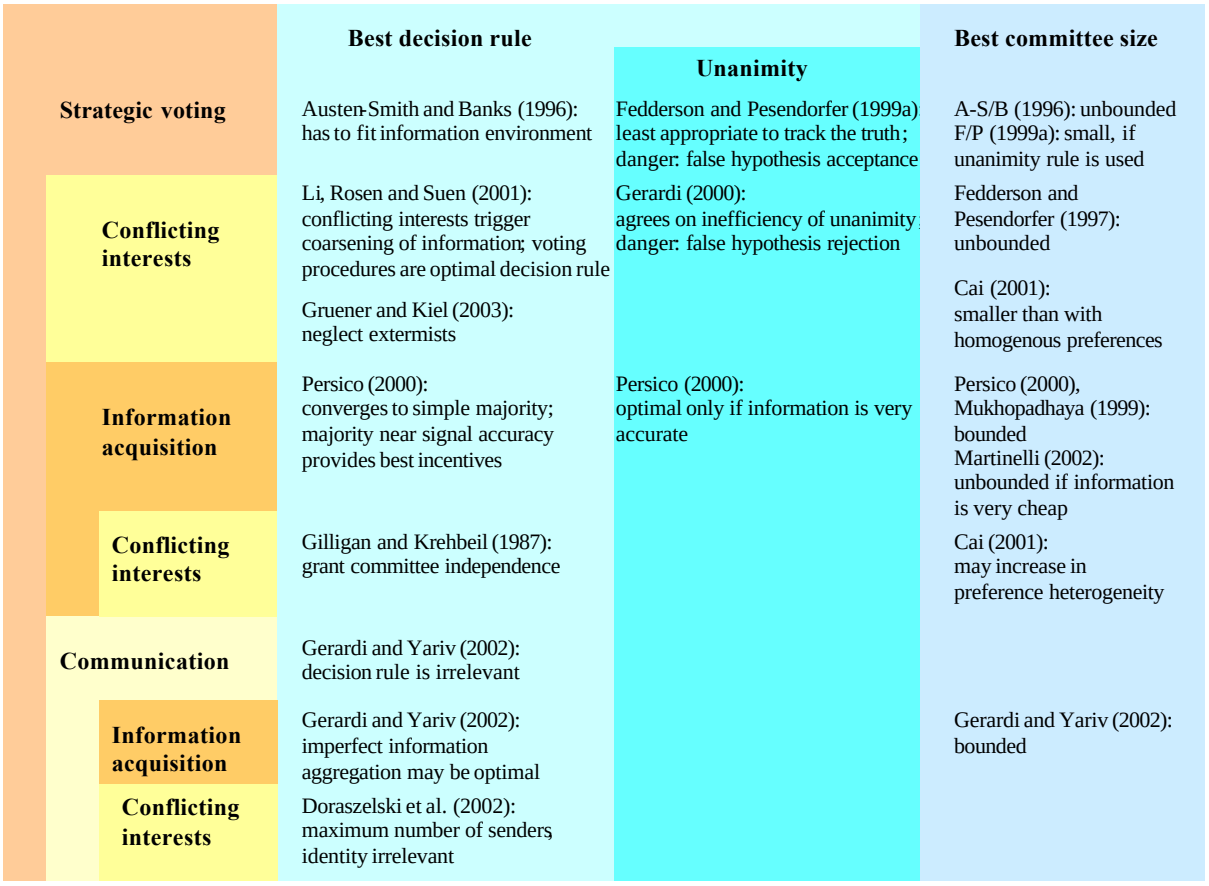


Figure 1: Overview of main game theoretic results on committee decision making

8.1 How large should a committee be?

The optimal size of a committee depends upon several issues. First, it plays an important role, whether the degree of individual informedness is exogenous or endogenous. In Condorcet's ideal world information is exogenous, i.e. individuals do not need to invest costly effort in order to obtain information. In such a set-up, large committees always lead to better results. Austen-Smith and Banks (1996) confirm this result when the majority rule is adjusted properly to the degree of informedness and the prior distribution of the different states of the world. Insincere voting is not a problem in such situations.

When information acquisition is costly, the optimal committee size is finite. This result is derived in Mukhopadhaya (1999), Nitzan (2001), and Persico (2000). According to Persico (2000), the optimal number of committee members is nonincreasing in information acquisition costs and ceteris paribus larger if (*i*) the costs of type I and type II errors are more similar, (*ii*) the prior is more diffuse and (*iii*) the signal is less accurate.

Note that the experimental results in Blinder and Morgan (2000) are not inconsistent with these theoretical findings, since theory also predicts that the quality of the decision initially increases in the number of committee members.

In a set-up with conflicting interests, Li, Rosen and Suen (2001) demonstrate that delegation to one single member is Pareto dominated by committee decision-making. When the committee rule is chosen appropriately, gains from sharing information outweigh distortions from information manipulation regardless of the extent of conflicts in the committee. The reason is that committee procedures are themselves chosen to control strategic misrepresentation given self-interested behavior.

According to Cai (2001), the optimal committee size is always smaller than the first best level when there are conflicting interests. The reason is that noisy reports by committee members with policy biases are not as informative as if there were no incentives to distort information. Optimal committee size can decrease or increase in the heterogeneity of committee members' policy preferences depending on information and participation costs. When information costs are so high that committee size is constrained by members' shirking tendency in gathering information, then a large committee can be functional. Moreover, in that case total social surplus can increase in preference heterogeneity.

8.2 Who should be in a committee?

According to Li, Rosen and Suen (2001), committee decisions improve if members of a committee have similar preferences. With increasing conflicts of interest, the area of disagreement becomes larger. This, in turn, leads to stronger incentives for strategic manipulation of private information and thus to an increase in expected costs (decrease in surplus).

Contrary to this result, Cai (2001) shows that - once there are conflicting interests among committee members - total social surplus may increase in preference heterogeneity. This can happen when moral hazard problems in information gathering severely limit the feasible committee size. Recall that information acquisition has two components in Cai's model: firstly, agents receive a signal about the state of the world and secondly, they become aware of their own preferences. In this model, two opposing effects are present: Heterogeneity in preferences has a direct negative effect on total social surplus, because it increases the noisiness of collective decisions. This effect is comparable to the one in Li, Rosen and Suen (2001). On the other hand, heterogeneity here provides additional incentives to gather information, since members with any policy biases can always manipulate policy in their ideal way. Thus, when the positive participation effect dominates the negative noisiness effect, increasing heterogeneity can increase total social surplus.

With regard to the quality of signals, committee decisions improve with the quality of individual information. This effect can be observed e.g. in the setting of Cai (2001): For a fixed committee size, more precise signals always improve the quality of policy decisions, thereby increasing total social surplus. When one committee member gains access to data of higher quality in the setting used by Li, Rosen and Suen (2001), then the other member takes advantage of the improved information by changing his voting threshold in order to defer the decision to the informed member. Thus,

better-informed members are decisive more often. When communication takes place, it is irrelevant whether it is the sender or the receiver of information who has data of higher quality (Doraszelksi et al. (2002)).

8.3 What is the optimal decision rule?

This survey of the game theoretic literature on committee decision making has made clear that the decision rule has to be adapted to the specific problem at hand. Austen-Smith and Banks (1996) have shown that the majority rule has to be adjusted to the distribution of signals and the initial prior distribution of states of the world. According to Persico (2000), the optimal decision rule converges to simple majority as the number of jury members grows.

According to Gerardi (2000), unanimity and the absence of communication lead to biased and undesired decisions in large committees. Under unanimity, the probability that an innocent is convicted converges to zero as jury size grows to infinity, but the probability to acquit the guilty converges to one. So, protecting the innocent comes at the prize of acquitting the guilty. Moreover, the probability that a convicted defendant is innocent converges to zero. Under any nonunanimous rule, which is defined as a fraction of votes required to convict the defendant, the probability to convict the innocent as well the probability to acquit the guilty converge to zero.

The introduction of pre-vote communication among committee members alters some of these results. Gerardi and Yariv (2000) show that if pre-vote communication is introduced into the Austen-Smith and Banks (1996) setting, the voting rule becomes unimportant. Doraszelski, Gerardi and Squintani (2002) show that even when agents have partially conflicting interests, voting outcomes improve when pre-vote communication is allowed. Moreover, it is irrelevant if it is the better or the worse informed agent who sends a message prior to voting. The authors conclude

that pre-vote communication and voting are perfect substitutes in the sense that the information not transmitted in the communication phase will be aggregated in the voting stage.

Gerardi and Yariv (2000) show that imperfectly aggregating the available information may yield a higher overall expected utility level than perfectly aggregating the information. The reason is that imperfect aggregation induces more players to acquire information. The positive effect of this may dominate the negative effect of wasting some information. However, imperfect aggregation mechanisms face a time-consistency problem. At the stage where the decision is to be made, committee members may agree not to stick to the decision procedure and to aggregate information efficiently. The use of imperfect mechanisms necessitates the ability to stick to the procedure.

9 Implications for Monetary Policy Committees

We conclude with a discussion of the implications of the game theoretic literature on committee decision making for the design of monetary policy committees. What are the conclusions that monetary policy makers may draw from this new game theoretic literature?

Some of the theoretical results that we have surveyed so far, do not seem to perfectly relate to the institutional set up which governs actual monetary policy decisions. One may just think of the literature that studies strategic voting in a set up where there is no communication among committee members. In monetary policy committees communication certainly plays a major role. One may therefore have doubts that the suggestions for the adjustments of decision rules which arise from strategic voting models should be used to guide the design of monetary policy institutions and of their voting rules. Nevertheless some useful insights may be drawn from the game theoretic literature. Some of these insights are discussed in this section.

9.1 Why monetary policy committees?

Monetary policy decisions are often made by committees and not by single individuals. The game theoretic literature that follows Condorcet's seminal analysis makes a strong case for decision making in committees. Delegation of monetary policy to a single decision maker can only be a boundary solution.

Recently, Gerlach-Kristen (2002) has formally elaborated on MPC decision making and provided some additional insights. She studies interest rate setting in monetary policy committees and addresses three main topics: the advantages of committee decisions over decisions by a single policy maker in the presence of uncertainty, the performance of three alternative decision procedures in such committees, and the reaction of the economy to shocks under these different decision procedures.

In the paper it is assumed that there is uncertainty about potential output, so that policy makers must form views about the state of the economy in order to set interest rates. If there was no uncertainty, policy makers could implement the optimal decision irrespective of the chosen procedure, since they share a common objective. Therefore, the first result of the paper, namely that it is preferable for monetary policy to be determined by a committee instead of a single policy maker if there is uncertainty about the state of the economy, is a direct application of the Condorcet Jury Theorem: the larger the committee, the better the decision.

Three different decision making procedures (the mathematically optimal procedure, averaging (mean) and voting (median)) are compared with respect to how much monetary policy conducted under uncertainty departs from that under full information. The author shows that if all members are equally skilled (in the sense that their observation errors have the same variance), averaging coincides with the

optimal procedure and is preferable to voting. The intuition is that under averaging, the decision is based on a broader information set, whereas under voting the policy is determined solely by the median voter's observation.

When committee members differ in abilities, voting may perform better than averaging. The performance depends on the degree of skill difference (only two different types are possible) and on the number of less able policy makers in the committee. The intuition is that in this case the optimal weights attached to the observations vary between committee members. Voting, by giving zero weight to all but the median voter's observation, is robust against differences in skills, whereas averaging attaches equal weight to all members' observations. Using simulations Gerlach-Kristen demonstrates that not employing the optimal decision procedure leads to larger and more prolonged deviations of the interest rate, inflation and the output gap from equilibrium.

Our discussion of communication and strategic voting points out that none of these results are fully convincing. In reality, monetary policy committee meetings are divided into two rounds. In the first, members exchange their views of the state of the economy and in the second, the interest rate decision is taken. Therefore, the model should allow for communication among committee members. Moreover, the paper ignores strategically motivated behavior. In the case of equally skilled members, this makes no difference, but if committee members differ in abilities, there exist incentives to manipulate policy outcomes or mimic behavior in the presence of uncertainty.

Despite these specific problems, we may conclude that the surveyed literature makes a strong case for making monetary policy decisions in a committee.[3]

[3]It should be noted that there are other justifications for the use of a committee that are not related to the literature that we surveyed here. According to Sibert and Mihov (2002), committees may lead to the appropriate degree of central bank flexibility. They argue that the desire to make a tough impression may yield incentives for high inflation committee members to mimic the low

9.2 The optimal size of a committee

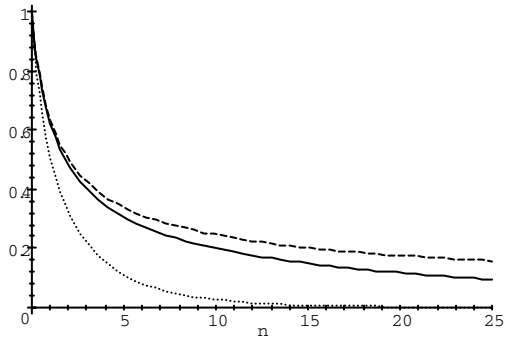
The literature on incentives for information acquisition in committees is certainly useful for the actual design of monetary policy committees. This literature points out that a central bank committee's decisions need not necessarily improve as the number of committee members increases. This is due to the fact that incentives for information acquisition are smaller when information acquisition is a public good. In a group, individual votes are less important because the probability of being pivotal declines.

The same reasoning applies in a setting in which communication takes place. Although the voting rule becomes unimportant because committee members with identical preferences agree on the collective decision as soon as all the signals are common knowledge, incentives to acquire private signals stay the same as in the setting without communication. Here "being pivotal" means contributing a signal that changes the collective decision - not via sincere voting, but by the direct announcement of the signal. It is easy to understand that both transmission mechanisms are identical. Thus, incentives again depend on the probability to contribute the decisive signal.

Figure 2 displays the probability that an individual decision maker casts the decisive vote (contributes the decisive signal) when the probability that a signal is correct is 0.6 and 0.8 respectively. As one can see the probability of being pivotal declines with the number of committee members. It is also smaller when committee members are better informed. In a committee consisting of 21 members of which 20 are al-

inflation ones. With large macroeconomic shocks the incentives to mimic are no longer large enough. The use of a committee yields better results than the use of a single policy maker who is tough. If one believes in the need for stabilization through committees, then, Sibert and Mihov indeed provide another nice justification for the existence of MPCs.

ready endowed with signals that are correct with probability 0.6 the last individual's signal is decisive with a probability of 11.7 percent. If committee members are better informed and receive signals that are correct with probability 0.8, the individual decision maker is decisive with a probability of only about 0.2 percent.



Probability of being pivotal with $n+1$ committee members. The individual error probabilities are 0.49 (dashed), 0.4 (solid), and 0.2 (dotted).

Empirical data on costs of information acquisition would be needed in order to make any additional statements about the optimal size of an MPC. Without such data, this issue is still left to individual judgement.

9.3 The voting rule

Another issue that is currently debated is whether MPCs should use majority or unanimity rule when they take policy decisions. The results in Feddersen and Pesendorfer (1998, 1999a) and Persico (2000) point out that unanimity rule is not a good standard for (monetary policy) committees. According to these theoretical models unanimity rule biases statements about observed information and leads to inefficient information aggregation. MPCs should therefore avoid to stick to the unanimity rule.

One may object that MPC members communicate before they vote. Therefore, one may believe that problems of insincere voting should not play a fundamental role

and that the voting rule is unimportant. However, experimental evidence by Guarnaschelli, McKelvey and Palfrey (2000) shows that pre-vote communication might only alleviate the problem of insincere voting. Therefore, it would be a wise strategy not to make unanimity rule the standard for monetary policy decisions.

It should however be noted that the use of majority voting does not necessarily imply that a central bank should publish its voting records. Some recent papers argue that a culture of collective responsibility may be useful for the central bank's relation to outside players. One can therefore well imagine a central bank that votes internally but is collectively responsible to the outside.[4]

It has recently been argued that one should attach different weights to the votes of different members of the ECB's council. Another conclusion that one may draw from the theoretical analysis of communication within committees is that there is no need to weight votes if these individuals share a common objective. When the ability of different individuals is known to the participants then weighting takes place when individuals take their vote. There is no need to assign different voting weights to different individuals.

The paper of Grüner and Kiel (2003) has some additional implications for effective information aggregation in MPCs where members differ in their view about desirable policies. In such committees extreme statements should be disregarded. Such extreme statements should only be used if preferences of committee members are strongly aligned.

[4]Gersbach and Hahn (2000) show e.g. that publication of individual voting records of central bank council members is initially harmful, since somewhat less efficient central bankers attempt to imitate highly efficient central bankers in their bid to get reelected. However, after reelection, losses will be lower when voting records are published, since the government can distinguish highly efficient from less efficient central bankers more easily and can make central bankers individually accountable. But the negative effects of voting transparency dominate and expected overall losses are always larger when voting records are published.

9.4 Who should be in a committee?

The literature on time consistency problems in monetary policy making has focused on the role of policy makers preferences for the emerging inflation rate. According to this literature delegation to conservative policy makers is the best the government can do in order to prevent an inflationary bias. The literature surveyed here provides additional insights in the role of the government's delegation decision.

Communication within the committee seems to be very useful in order to improve the quality of the decision. Communication makes the voting rule unimportant in a situation where preferences are identical but individual signals differ. With conflicting interests the ability of a committee to communicate efficiently is reduced. Picking a homogenous committee may instead improve the quality of the decisions because it facilitates internal communication.

Another conclusion that one may therefore draw is that monetary policy committees do not benefit from a situation where there is no common understanding of the role and objectives of monetary policy making. This has straightforward implications for the optimal composition of common currency areas and the central bank's monetary policy committee. Heterogeneity of views of committee members is not always beneficial.

9.5 Relation to the outside

There is an extensive literature on the role of the independence of the central bank which mainly focuses on the elimination of an inflationary bias[5]. The analysis of

[5]Faust (1996) has a model that explicitly models decision making by committees in this context. He makes the point that there need to be a strong conservative fraction in the committee in order to eliminate the inflationary bias.

incentives for information acquisition in committees points out that the independence of a committee has a different effect which may also be quite important. Granting a committee independence may enhance the quality of its research. Incentives for information acquisition in the committee are higher if the committee can rely on the fact that policy is based on its opinion only. A dependent committee has little incentives to acquire information and is therefore less likely to acquire expertise.[6] [7]

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[6] See Section 3.3.

[7] This result is at odds with the one in Lohmann (1992). She argues that the possibility of overruling the decision of the central bank induces some desired central bank flexibility. The difference is due to the fact that Lohmann considers a setup with perfect information whereas Gilligan and Krehbeil focus on incentives for information acquisition.

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