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Review

Information aggregation and communication in committees

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In this paper, we attempt to explain the underlying strategic incentives confronting individuals when they must make a collective decision over a set of alternatives and each has information that is decision-relevant for others. A significant literature has emerged in formal political theory over the past several years that focuses on such problems, paying particular attention, first, to the extent to which voting can be expected to aggregate committee members' information and, second, to the role of communication among committee members prior to voting. *Inter alia*, this literature reveals a surprisingly subtle interaction between the voting rules used to make decisions and the incentives for committee members to share information prior to voting.

Keywords: information; communication; committees

1. INTRODUCTION

Rather than providing a necessarily discursive summary of the formal literature on information aggregation and communication in committees, our goal in this paper is to explain the underlying strategic incentives confronting individuals when they must make a collective decision over a set of alternatives and each has information that is decision relevant for others. A canonical example of this class of problem is that of a jury charged to decide whether a defendant is guilty or innocent; all jurors prefer to convict the guilty and acquit the innocent, but each individual is unsure of the defendant's status in this respect. A significant literature has emerged in formal political theory over the past several years that focuses on such problems, paying particular attention, first, to the extent to which voting can be expected to aggregate committee members' information and, second, to the role of communication among committee members prior to voting. *Inter alia*, this literature reveals a surprisingly subtle interaction between the voting rules used to make decisions and the incentives for committee members to share information prior to voting.

2. STRATEGIC VOTING WITH PRIVATE INFORMATION

To fix ideas, it is helpful to consider a simple example. The dean of a college has to decide whether to hire a job candidate (Don). The dean would like to hire Don if and only if all of his papers are promising. Don has a long vita, too long for the dean to read. Assuming he is qualified to recognize promising research in the candidate's field, the dean might read a small subset of Don's papers and see if any look promising. In that case, the dean might choose to hire Don if all of the papers he does read happen to be promising and not otherwise. Similarly, because he cannot read all of Don's papers, he might choose not to hire at all in which case he runs the risk of rejecting Don when in fact all of Don's papers are promising. But in taking this approach, the dean runs the risk of hiring Don when not all of his research is promising, illustrating the problems facing a decision-maker with imperfect information about the relative merits of competing alternatives. Decision-makers (like deans) often try to minimize the likelihood of errors by appointing a faculty committee to look at job candidates and make recommendations. The advantage of a committee is that it is, in principle, better informed collectively than any individual on the committee (although each individual may read no more papers than the dean, the committee as a whole may read all of the papers). And in 1785, de Condorcet (1994) demonstrated that when committee members in such situations vote in a way that reflects their information (i.e. they *vote informatively*), the committee decision minimizes the probability of mistakes (see also Ladha 1992).

However, what was not appreciated until recently is that voting creates incentives for committee members not to vote informatively even when all committee members share the same objectives. To see this, suppose the dean appoints a faculty committee of three people (Alice, Bob and Chris) who must choose whether or not to hire Don. The dean instructs the committee that the candidate will be hired if and only if a majority of the committee votes in favour. Each member of the faculty committee, like the dean, favours hiring a candidate if and only if all of his research papers are 'promising'. For the moment, that is, the committee members' preferences are presumed to satisfy *common values* with respect to the decision:

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conditional on having the same information, all individuals' preferences over final outcomes are identical. The committee decides to divide responsibility for reading Don's papers equally among themselves, so that each member reads a different set of papers. The dean then hires Don if a majority votes in favour. How should a faculty member, say Alice, vote?

Alice knows that her individual vote does not always determine the outcome; in particular, her vote is *pivotal* when the other faculty members are split with one voting in favour and the other voting against. Alice also knows that because each committee member reads a distinct subset of Don's papers, all three of them have *private information* that is potentially relevant for every committee member's decision. For example, if Alice has read some papers that are not promising, then she knows that no person on the committee would like Don to be hired, including those who have read only promising papers. Similarly, Alice knows that even if she has read only promising papers, Don should not be hired if either Bob or Chris has read a paper that is not promising. As a result Alice's problem of how to vote in the committee is qualitatively different from that of an individual decision-maker choosing in isolation (e.g. the dean above).

Suppose that not all of Don's papers read by Alice are promising. Clearly, since everyone favours hiring Don only if all his research is promising, Alice should vote against hiring Don. But what if all of the papers she has read are promising? Alice's decision depends on how she thinks Bob and Chris are voting. If Alice believes that Bob and Chris vote informatively to hire Don if and only if all of the papers each individually reads are promising, she must also believe that the only event in which her vote is pivotal is when exactly one of the other two has read papers that are not promising while the other has read only promising papers. But in this case she would rather vote not to hire Don. That is, in situations with common values and private information, informative voting behaviour makes the event that one is pivotal informative about what others know. Since one's vote only matters in the event it is pivotal, individuals have an incentive to condition their vote not only on their own private information but also on the information that others must possess in that event. This is the case even though Alice does not know how others have voted and may believe it to be very unlikely that her vote is pivotal.

Returning to Alice's problem of how to vote, it seems from the above that if others are voting informatively, then Alice should not and instead she ought always to vote against hiring Don. But then similar reasoning applies equally to Bob and Chris, further complicating Alice's decision. Formally, such situations are properly analysed as games rather than as individual decisions. Game theory asks what strategic behaviours by committee members constitute an *equilibrium*: a list of decisions or strategies, one for each individual, that together constitute a mutually consistent set of best responses. In other words, in equilibrium, each individual correctly anticipates the behaviour of others and chooses optimally given their correct beliefs about that behaviour.

A large literature exists in formal theory exploring the relationship between voting rules and information aggregation when, unlike in the Condorcet jury theorem, voters are strategic (early contributions include Ordeshook & Palfrey 1988; Austen-Smith & Banks 1996; Feddersen & Pesendorfer 1996, 1997). As the preceding discussion suggests, such strategic behaviour can be quite subtle and, perhaps, prima facie implausible as a description of how people actually vote. However, there now exists an experimental literature that finds that individuals do indeed seem to behave in a manner consistent with the theory (see, for example, Guarnaschelli *et al.* 2000; Battaglini *et al.* in press *a*,*b*).

3. VOTING RULES AND TALK

It can be shown that informative voting by all committee members is often not an equilibrium. As a result, in small committees, equilibrium behaviour produces outcomes that are sometimes unsatisfactory; that is, there exist situations in which the candidate is not hired when all of his research is promising and others in which he is hired when not all of his research is promising. Say that an outcome from equilibrium voting satisfies *full information equivalence* if the result of the voting is always the same as the result would be if all private information were shared. Feddersen & Pesendorfer (1996, 1997) demonstrated that Condorcet's basic insight is robust to strategic behaviour for sufficiently large committees or electorates under many (non-unanimous) voting rules, even without the assumption of common values (see also Wit 1988; McLennan 1998). But our interest in this essay is with small committees and, in this setting, Austen-Smith & Banks (1996) demonstrated that voting alone may fail to satisfy full information equivalence if the voting rule is not aligned with committee members' preferences and the information environment. One approach to the problem of aggregating information in small committees, therefore, is to choose the voting rule appropriately.

Consider our running example (with common values) and suppose that instead of using majority rule in committee, the dean requires a unanimous vote in favour of Don for him to be hired. Under this rule, if Alice believes as before that both Bob and Chris are voting informatively, then she must also believe that the only event in which her vote is pivotal is when both are voting in favour of hiring Don. Therefore, conditional on being pivotal, Alice's optimal response is to vote informatively as well, that is Alice should vote to hire Don if and only if all the papers she has read are promising. Thus, informative voting by all committee members constitutes equilibrium behaviour and assures full information equivalence: Don is hired if and only if all of the papers read by the committee are promising.

The relationship between voting rules and information aggregation in committees is an important concern in the formal literature and one to which we return shortly. Voting rules, however, are often fixed prior to knowing the details of any particular decision or information environment and cannot be tailored to

each and every separate collective choice (see Austen-Smith & Banks 1996; Feddersen & Pesendorfer 1998). An alternative and, at least for small committees with common values, obvious solution to the potential failure to aggregate information under majority rule is to have everyone on the committee share their private information before voting. Suppose, in our example, that Alice, Bob and Chris recognize the possible difficulties with simply voting and decide to meet and talk prior to voting. Then they might share their private information with each other and so condition their vote on all of the available information about Don. But sharing information in conversation turns out to be problematic, both substantively and technically.

The canonical formal literature focuses on the extreme case of *cheap talk*. An individual sends a message (makes a speech) from an abstract set of possible messages; a listener hears the message and draws an inference about the speaker's private information. The speaker anticipates the different inferences listeners might make and chooses the message that, given his or her preferences, elicits the best possible behavioural response from the listener. If the speaker suffers no consequences for making any particular speech beyond the behaviour that her speech elicits and if the listener has no independent way to verify the veracity of the content of the speech, we say talk is cheap. The cheap talk model, therefore, allows for the possibility of deception and opacity. For example, suppose that Alice has not read any promising papers by Don. In the pre-vote meeting with Bob and Chris, she might tell them that in fact all of the papers she read are promising, even though that is not the case. However, assuming Bob and Chris are rational listeners, they take account of Alice's incentives and, perhaps, discount her speech accordingly. For Alice to be credible, it must be the case that whatever her private information, she prefers to tell the truth (see Crawford & Siobel 1982; Austen-Smith 1992; Farell & Rabin 1996).

Of course, in the real world, talk may not (always) be cheap: Alice might feel bad about dissembling, or she might worry that others discover her misrepresentation and impose some sort of sanction, or Alice might be able to reveal credibly that she has read a promising paper by showing it to the others. Nevertheless, the assumption of cheap talk is a particularly useful baseline from which to evaluate the incentives for individuals to share information in various situations. Indeed, even when talk is cheap, if the committee shares common values, then talking prior to voting creates an incentive for everyone to report their private information truthfully and, subsequently, to vote unanimously to yield full information equivalence. This simple solution to difficulties with information aggregation in committees is explored in Coughlan (2000) for a wide class of voting rules. And although quite intuitive, it proves convenient to walk through a simple model of communication that supports the result.

To this end, suppose that, prior to voting, each committee member independently writes a report saying essentially that either all or not all of the papers read are promising, and sends it to everyone on the committee. In effect, this simple communication structure serves as a kind of straw poll. Each committee member reads the others' reports and then submits their vote to the dean. Suppose that all of the papers Alice read are promising and she is considering what to report to the others. If Alice believes Bob and Chris are reporting truthfully and expect her to do so likewise, Alice anticipates that Bob and Chris will vote to hire Don if and only if all report that they have read only promising papers; thus Alice's report is pivotal at the communication stage only if Bob and Chris report that all of the papers they have read are promising. If Alice falsely reports that Don's papers were not all promising, the result is that Don is not hired (because Bob and Chris will vote against), so she has an incentive to report truthfully; and it is easy to confirm that, because they share common values, the same is true in the event that Alice has read some unpromising papers by Don.

It is important to observe here that the preceding argument did not depend on whether the committee votes under majority rule or unanimity rule. Moreover, the event in which Alice's *report* is pivotal under majority rule *at the communication stage* (that is, given truthful information sharing, both Bob and Chris report that they have read only promising papers), is distinct from the event in which Alice's *vote* is pivotal *at the voting stage* (that is, given informative voting, exactly one of Bob and Chris is voting to hire Don). Indeed, given common values and truthful communication prior to the voting stage, no committee member is pivotal at the voting stage under majority rule since all vote unanimously one way or the other, depending on the realized distribution of reports. Under unanimity rule, however, every committee member is pivotal at the voting stage following full revelation during the communication stage and, just as in the case of absent communication, every member has an incentive to vote informatively.

With common values, talk can compensate for inadequate voting rules. While the particular communication protocol used in the example above (reports etc.) is highly stylized, the basic intuition is quite robust. For example, the committee members could meet and talk in sequence as they would in a real meeting. In all cases in which a member's speech influences the voting outcome common values guarantee, the member wants to speak truthfully. Perhaps unfortunately, this insight does not extend beyond the common value setting. When the assumption of common values is relaxed, an interesting and subtle connection between voting rules and incentives to share information emerges.

4. BIASES, BELIEFS AND HETEROGENEITY

The assumption that committee members share common values is not general and, when it fails to hold, allowing people to talk prior to voting introduces a further layer of strategic complexity beyond that of voting with private information. First, however, it is necessary to be a little more precise about how preferences and beliefs are normally modelled in this literature.

To discuss a world without common values, it will be useful to introduce some additional terminology. We say that committee members have *beliefs* and *biases*. In the formal theory literature, beliefs are modelled as conditional probabilities: conditional on some event, an individual assigns a probability to each of a set of possible *states of the world*. In our example, there are four states of the world: zero, one, two or three committee members have read exclusively promising papers. An individual reads some subset of Don's papers. If she has read an unpromising paper, then she believes that one state has surely not occurred, *viz.* that Don has not written only promising papers, but is unsure as to what state has in fact occurred. By contrast, if all of the papers Alice read were promising, then she assigns different probabilities to each of the states.

The example further illustrates that beliefs depend not only on individuals' private information, but also on the behaviour of others. This is transparent if, say, Alice knows that Bob and Chris vote to hire Don if and only if they have read exclusively promising papers and she observes them cast split votes. In such a case, even if Alice has read only promising papers, her belief conditional on this event is that Don has, in fact, written an unpromising paper and so should not be hired. The surprising thing is that Alice need *not* observe the votes of others to draw this inference: because the outcome is determined by voting, necessarily her vote only matters when the votes of the others are split and hence she may draw the inference that exactly one of Bob or Chris (it does not matter which) has read an unpromising paper.

Committee members also have *biases*, that is, for a given state of the world, an individual's bias describes his or her preferences over whether or not to hire Don. Under common values, all committee members share the same bias; in the example, to hire Don if and only if he has written only promising papers.

Coughlan's (2000) result cited earlier shows that talking can compensate for an inappropriate voting rule and induce full information equivalence. But this result turns out to depend crucially on the presumption of common values. Coughlan (2000) and Austen-Smith & Feddersen (2005, 2006) showed that even a small degree of uncertainty about whether there are common values in the committee leads to two things. First, there is no voting rule that can induce all committee members to vote informatively and, second, whatever voting rule is chosen, there may be incentives for the members not to reveal their private information prior to voting. It is easy to illustrate this observation by perturbing our running example for the extreme case, that is, where there is certainty that people have different biases.

Suppose everyone knows that Bob and Chris prefer to hire Don if and only if he has written only promising papers, but Alice wants to hire him if and only if he has written at least one promising paper. Recall from the argument above that, under common values, everyone voting informatively on the committee could not be an equilibrium under majority rule, but such behaviour did constitute an equilibrium when a unanimous vote is required to hire Don. Without common values, however, this second conclusion fails. If only one negative vote is needed not to hire Don and, as before, Alice believes both Bob and Chris are voting informatively, then Alice is pivotal if and only if both of the others are voting in favour of Don which implies that neither of them has read an unpromising paper. Hence Alice prefers to vote uninformatively in favour of hiring Don however many unpromising papers she reads.

Under common values, everyone has an incentive to share their information truthfully at the talk stage. To see that this conclusion does not hold without common values, suppose each member is believed by the others to report their private information truthfully. Now assume that at least one of Don's papers that Alice reads is not promising. When does it matter what Alice reports? If Alice's report matters at this stage, then it must be because both Bob and Chris report that all the papers that they have read are promising, otherwise both will vote against hiring Don and he will not be hired under either majority or unanimity rule. (This follows because both Bob and Chris have the most demanding bias; if either reads a paper that is not promising then they would, by hypothesis, have reported that information during the talk stage and both vote against hiring.) Therefore, conditional upon Alice's report being pivotal, she has an incentive to report falsely that all the papers she has read are promising. Unlike the common values setting, neither talk prior to voting nor changes in the voting rule itself are sufficient to guarantee full information equivalence.

An important feature of the preceding scenario is that Alice knows that Bob and Chris have biases distinct from her own. Austen-Smith & Feddersen (2006) showed that the combination of bias uncertainty and non-unanimous voting rules can sometimes recover full information equivalence (see also Meirowitz 2006, 2007). Alice's incentive not to reveal her information in the preceding discussion arose because she knew that the two others had a more stringent standard for hiring. When bias uncertainty is introduced, however, Alice must be concerned that her colleagues may share her bias and, therefore, by misinforming them she may cause them to vote against their interest and hers.

To illustrate the role of bias uncertainty, suppose that Alice is unsure whether Bob and Chris share her bias and prefer to hire Don if any of his papers are promising or, as above, both prefer to hire Don only if all of his papers are promising. Under the assumption that Bob and Chris truthfully reveal their private information and share Alice's bias, it follows that the only event in which Alice's information influences Bob's and Chris's vote is when neither have read any promising papers. In that case, if Alice has not read any promising papers either but claims she did, the result is that both Bob and Chris vote for Don while Alice votes against. Under majority rule, Don is hired even though everyone on the committee would prefer otherwise. Thus Alice prefers to reveal her information truthfully. On the other hand, when Bob and Chris have a more demanding bias than Alice, Alice's information is only pivotal when both Bob and Chris have read exclusively promising papers. As before, Alice prefers to mislead her colleagues in this event. Under majority rule,

Alice's decision to reveal her information truthfully depends upon which event she thinks is more likely: the event that Bob and Chris share her bias and have information similar to hers, or the event that they have more stringent biases and have information different from hers. If it is more likely that Alice's information is similar to that of Bob and Chris then, by conditioning on being pivotal, Alice puts more weight on the event that they share her bias too and, therefore, prefers to tell the truth.

Note that Alice's incentive to reveal information truthfully under majority rule does not extend to unanimity rule. Under unanimity rule, Alice can always ensure that Don is not hired by voting against him. It follows that she does not need to worry about the event in which she has the same preferences as Bob and Chris, but misleads them into voting in favour of Don, for in this case she can veto Don being hired at the voting stage. Instead, the only event Alice must worry about occurs when she prefers that Don be hired but the other two do not, an event in which Alice has a strict incentive *not* to report her information truthfully. This basic intuition is very general and leads to one of the main results in Austen-Smith & Feddersen (2006): full information revelation is not possible under unanimity rule but may be achievable under other, non-unanimous, voting rules (see also Doraszelski *et al.* 2003).

The Austen-Smith and Feddersen result exploits the stylized communication protocol described earlier, in which each committee member makes a report simultaneously prior to voting. Suppose instead that committee members take turns speaking as they might in a meeting. Later speakers can then condition their reports on what earlier contributors have revealed. Although apparently more natural, this protocol has the unfortunate by-product that later speakers can rule out some pivot events. In particular, if Alice is the last speaker and has heard Bob and Chris both say that they have read only promising papers, she knows that her speech only matters when the others have more stringent biases than herself. Alice has an incentive not to report truthfully but to induce Bob and Chris to vote for Don by saying that she too has read only promising papers, even when she has not. Formalizing this logic more generally, Van Weelden (2008) shows that Austen-Smith & Feddersen's (2006) result on the impossibility of full information sharing under the unanimity rule extends to all voting rules when communication is sequential. In other words, sequential public communication among committee members, although more appealing descriptively, is in fact deleterious for information revelation.

5. THE STORY SO FAR

It is useful to sum up. In the simplest, non-trivial, setting in which three committee members with identical biases, or common values, make a decision between two given alternatives, if the members have private information about the relative worth of the alternatives under consideration, the voting rule may impede reaching full information equivalent to committee decisions or outcomes (see Austen-Smith (1990) for a model of information aggregation with multiple alternatives). Two intuitively appealing solutions to addressing such problems are, first, to tailor the voting rule to align incentives and induce individuals to vote informatively and, second, to allow committee members to communicate prior to voting.

However, we have observed that even minimal deviations away from common values make it impossible to use voting rules alone to induce full information revelation. When there is bias uncertainty among committee members, so no member is sure of the distribution of biases across the committee, it is sometimes possible to combine non-unanimous voting rules with pre-voting talk and recover full information equivalence. Under a more realistic, sequential, view of information exchange as might occur in real committee deliberations, full information equivalence turns out to be difficult for any voting rule, at least when speaking constitutes cheap talk.

The model of a committee using a simple voting rule preceded by cheap talk is useful for isolating the key underlying strategic incentives that may frustrate effective information aggregation. But there are many other ways in which committees might be organized, communication could take place or a final decision could be reached. For example, a subset of committee members might meet prior to any open discussion of the alternatives in committee, or there could be a disinterested mediator used to collect and disseminate private information, and so on. The question such possibilities raise, therefore, concerns the best way to organize committee communication to achieve collectively desirable outcomes, in particular, full information equivalence.

6. GENERAL COMMUNICATION IN COMMITTEES

It turns out that even without specifying details of exactly how people communicate prior to voting, it is possible to draw a critical distinction between unanimity and non-unanimous voting rules. As before, by voting rule we mean that a given alternative is chosen if and only if it receives q or more votes. Under non-unanimous voting rules with at least three committee members, if everyone on the committee votes for the same alternative then an individual's vote cannot be pivotal at the voting stage; given everyone is expected to vote for the same alternative under any non-unanimous rule, changing any one person's vote does not change the outcome. Hence, any individual might as well vote with the consensus as vote against, in which case the only strategic issue at stake is the impact of an individual's report on the consensus that eventually forms. In an elegant contribution, Gerardi & Yariv (2007) exploited this observation to show, first, that any level of information aggregation achievable under any possible protocol for communication with some non-unanimous voting rule is equally achievable under any other such rule and, second, that the level of information aggregation achievable under unanimous voting rules is never more and can be strictly less than that with non-unanimous rules.

On the positive side, the Gerardi and Yariv result suggests that the voting rule itself is essentially

irrelevant relative to the way in which communication takes place. This finding provides support for the approach taken in the informal (i.e. not game theoretic) literature on deliberation that emphasizes the importance of argument and reasons rather than the interplay of voting rules and communication. Important contributions in the informal literature on communication collective choice include the essays and references in the collections by Bohman & Rehg (1997) and Elster (2000). Landa & Meirowitz (2007) attempted to connect the more formal approach reviewed in the current essay to the concerns addressed in the informal literature. See also Hafer & Landa (2007) and Glazer & Rubinstein (2001, 2004), who develop alternative models of argument and communication to those deployed in the canonical game-theoretic approach. The Gerardi and Yariv result, however, does not imply that details of the communication environment are irrelevant. Indeed, there is a growing formal literature that explores such details. In particular, it is worth noting recent efforts to incorporate incentives to acquire information (see Persico 2004; Gerardi & Yariv 2008).

The literature on communication in committees focuses on the relationship between communication and voting. The central question in this literature concerns how committees might best share information given that they ultimately make collective choices by voting, a question that remains open. To provide an answer, the issue of what the objectives of a heterogeneous committee ought to be has to be resolved and this is far from being a trivial problem. Indeed, to evaluate the performance of any *specific* communication protocol and voting rule relative to a given objective, it is necessary to identify the best that is achievable relative to that objective under any *conceivable* protocol or rule. In the simultaneous cheap talk setting, Austen-Smith & Feddersen (2005, 2007) found a variety of partially informative equilibria under both majority and unanimity rule for three person committees. Comparing these equilibria suggests majority rule is superior to unanimity rule here, at least with respect to full information equivalence. But such results are very limited: they fail to establish any benchmark for what is in fact more generally achievable even within the confines of this simple structure. To date, such results have proved elusive (but see Meirowitz (2006) and Gershkov & Szentes (2009) and for some steps in this direction).

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