Information Aggregation and Equilibrium Selection in Committees

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In the last decade, Marie Jean Antoine Nicolas de Caritat marquis de Condorcet's (1785) theory of committee decision making has emerged as workhorse model in political economy, particularly voting theory. In its simplest modern formulation, the "Condorcet Jury Model" (CJM hereafter) features a committee of size n that is faced with a binary policy. The optimal policy is the same for all members, but depends on an unknown state of the world. Each member of the committee receives some private information about the state. The policy is determined by an election in which each voter can vote for either alternative, and the profile of votes is aggregated into a group decision according to some voting rule such as majority or unanimity with a status quo. The voting procedure also specifies the order in which voters cast their votes.

In this framework, one can compare voting behavior and informational efficiency under alternative voting rules and procedures, a methodology referred to as the *information aggregation approach to elections.* The past decade has produced a large and growing set of results on this topic, under various modifications to the basic CJM.[1] This resurgence of interest in Condorcet's approach was sparked by a key observation of David Austen-Smith and Jeffrey Banks (1996) that "naive" voting is generally not a Nash equilibrium of the voting game. That is, the optimal way to vote in a multi-person committee is not usually the same as the optimal way to vote in a committee of one, an issue overlooked by Condorcet and other non-game-theoretic analysis of his model. In fact, a voter's strategic incentives generally depend on all the variables of the model: the size of the committee, the voting rule and procedure, the information structure, preferences, and so forth. Because such a simple model offers rich insights into the strategic considerations faced by voters, the CJM has played a prominent role in enhancing our understanding of voting mechanisms.

[1] In addition to the other references in our introduction, see Timothy J. Feddersen and Wolfgang Pesendorfer (1996, 1997), Andrew Mclennan (1998), Roger Myerson (1998), Michael Chwe (1999), Peter Coughlan (2000), Arnaud Costinot and Navin Kartik (2007), and Dino Gerardi and Leeat Yariv (2007), among others.

However, some of the equilibrium properties of these common value elections can be unintuitive. In a striking example of this, Feddersen and Pesendorfer (1998, FP hereafter) have shown that in the context of juries for criminal trials, requiring a unanimous vote for conviction may actually lead to more convictions than using majority rule. Because such theoretical predictions and the equilibrium strategies that underlie them are seemingly unnatural, they are particularly good candidates for empirical testing. Unfortunately, testing the theory with field data is virtually impossible because of the sensitivity of the results to the exact parameters of the model, and there are no obvious data sets available for such a purpose.[2] Consequently, in this paper, we adopt an experimental approach to understanding common value elections.

This paper examines two interrelated issues in the information aggregation approach to voting. The first question that we address is robustness. Since the goal of the theory is to provide a *general framework* to analyze voting in committees, is it the case that committees that are fundamentally different respond in similar ways to their asymmetric information? We address this question by comparing *ad hoc committees*, like juries or expert panels, with *standing committees*, like boards of directors, judicial panels, or town councils. An important difference between the two is that ad hoc committees have a short life and address a very limited set of issues (often only one, as with trial juries in the US), whereas standing committees have a long life, and the members of the panel therefore engage in a repeated game. Hence our first question is: Do the theoretical predictions of the CJM apply equally well (or equally poorly) to the behavior of ad hoc committees and to the behavior of standing committees?

One reason to believe that there could be a difference is that the CJM usually has many equilibria. Broadly speaking, a common value election involves coordination among voters and thus, admits multiple equilibria that can be ranked by the Pareto

[2]The closest would be some data on real jury voting, but the details of the information structure is not clear, and neither is the actual voting procedure used (since juries operate behind closed doors).

criterion. Moreover, when committee members vote sequentially, there are asymmetries across voting positions which may be relevant to behavior. Indeed, it has been often suggested that sequential voting would give rise to *momentum* effects, where later voters tend to follow the choices of earlier voters. Recent theoretical work on this question by Eddie Dekel and Michele Piccione (2000) and S. Nageeb Ali and Kartik (2007) has demonstrated that strategic voting in sequential elections can be both history-independent and history-dependent.[3] This leads to the second question: Can the timing structure of the voting procedure lead to selection of different equilibria?

There have been only a few prior experimental studies of voting behavior in the CJM.[4] The most relevant for us is the first study of strategic voting under unanimity rule, by Serena Guarnaschelli, Richard D. Mckelvey, and Thomas R. Palfrey (2000, GMP hereafter). They found that committee members often voted strategically in the sense of sometimes casting a vote in contradiction to their private information about the state of the world, as is predicted to occur in equilibrium. GMP also found that the comparative static predictions about the voter strategies under unanimity rule were qualitatively correct (more strategic voting in larger committees), although the changes in observed behavior were not as large as predicted by theory. An important consequence of this deviation from equilibrium strategies was that many of the predictions of FP with respect to information aggregation and efficiency are rejected by the data.

The GMP study only considered ad hoc committees which met once and then were dissolved. In the study reported here, we attempt to replicate their results with standing committees that meet repeatedly. Moreover, GMP only considered simultaneous voting. Here, we compare behavior under sequential and simultaneous voting procedures.

[3] The aforementioned authors prove results for a wide class of voting rules, including unanimity rule, which is our focus here. In the context of majority rule, see also Jörgen Wit (1997), Mark Fey (2000), and Steven Callander (2007).

[4] See Angela Hung and Charles R. Plott (2001), Krishna Ladha, Gary Miller, and Joe Oppenheimer (2003), and Jacob K. Goeree and Yariv (2007).

I Experimental Design and Procedures

The laboratory study implemented several variations of the following game based on the CJM. There is a committee (e.g., a jury) with n members. Nature randomly chooses a payoff-relevant state of the world, ω, from the set $\Omega = \{G, I\}$.[5] Each state is chosen with equal probability. Members do not observe the selection of the state, but each receives a private signal, s_j, about the state. Each signal $s_j \in \{g, i\}$ is a conditionally independent Bernoulli random variable where $\Pr(s_j = g|\omega = G) = \Pr(s_j = i|\omega = I) = p > \frac{1}{2}$. Each member j casts a vote $v_j \in \{c, a\}$ for one of two outcomes in $X = \{C, A\}$, and cannot abstain.[6] All the commitees reported in this study operated under unanimity rule, which requires all n members to cast a c vote in order for C to be the committee decision. Members have identical preferences which depend only on the group decision and the state of the world: $u(C, G) = u(A, I) = 1$, and $u(C, I) = u(A, G) = 0$.

Our experimental design has three treatment variables: committee size (n), committee type (ad hoc or standing), and voting procedure. We consider committees of two different sizes, 3 and 6. We conduct two different voting procedures that differ in their timing: simultaneous voting and sequential voting. The former is like a secret ballot, where individuals vote after receiving their private signals, but observing nothing else. In the sequential voting procedure, members vote one by one in a pre-specified sequence, with each voter observing the votes (but not the private signals) of those before them. In the ad hoc committee treatment, subjects were randomly rematched into groups of size n at the start of each period. In contrast, in the standing committee treatment, subjects were randomly grouped at the start of the experiment, but the group composition remained constant during the entire experiment.

While our procedures are standard in experimental economics, there were several differences across treatments, including the subject pool, instructions, software, payoff

[5] Throughout, read "G" = Guilty and "I" = Innocent.
[6] Throughout, read "C" = Convict and "A" = Acquit.

salience, etc. The simultaneous ad hoc committee data are from the GMP study. The sessions for that study were conducted in 1997 and used 48 Caltech subjects who participated in 15 committees with unanimity rule.[7] The Caltech experiment used a program written in C++. The sequential ad hoc committee data were collected at UCLA in 2007, and in these experiments each subject participated in 30 committees. The sequential ad hoc committee sessions were conducted using the JAVA-based Multistage program (http://multistage.ssel.caltech.edu) and verbal instructions including overhead slides. Finally, the standing committee data were collected at UCLA in 2003, using a Virtual Basic program and online instructions.[8] In these experiments, subjects made 30 committee decisions.[9] The three programs differed somewhat in the user interface for entering decisions. As we will show below, the experimental results seem to be quite robust to these variations in protocols and procedures.

In total 222 subjects participated in the experiments (this includes the GMP subjects). Average earnings in the UCLA experiments were $23.72, plus a fixed showup payment and the experiments lasted somewhere between 40 and 60 minutes.[10]

II Results

We focus our discussion of results mainly on the differences between ad hoc and standing committees, dividing the discussion between simultaneous and sequential voting. While we compare and contrast the behavior in different treatments, we do not explictly test whether differences in behavior are statistically significant, because

[7] Each of these subjects also participated in additional committees with different voting rules and procedures, data that we do not use in this paper. See Guarnaschelli et al. (2000) for details.

[8] We would like to thank Jos Theelen for programming the standing committee experiments.

[9] In the UCLA experiments, subjects were recruited by mass email invitations to registered members of a large subject pool of UCLA students, maintained by the California Social Science Experimental Laboratory.

[10] In the UCLA sessions, subjects earned $1.00 for each correct committee decision and $0.10 for each incorrect committee decision. In the GMP experiment subjects earned $0.50 for each correct decision and $0.05 for each incorrect decision.

observations of group behavior are potentially correlated across rounds. Instead, we simply focus on qualitative/economically substantive differences. We discuss this issue further in our conclusion.

II.A Simultaneous Voting Procedure

First we ask: Is behavior different between ad hoc committees and standing committees operating under unanimity rule with simultaneous voting? The top part of Table 1 answers that question with a clear *no* in terms of aggregate behavior. It reports the fraction of observations where individuals voted to convict in each treatment, broken down by whether they had received an innocent or guilty signal. The number of observations is shown in parentheses. The final row of Table 1 shows the predicted frequencies of the unique responsive symmetric equilibrium, in which voters with guilty signals always vote to convict, and voters with innocent signals vote to convict with probability $\sigma^*(n) \in (0, 1)$.[11] There is essentially no difference between ad hoc and standing committees in the probability of voting to convict with either a guilty or innocent signal when $n = 3$, and only a negligible difference when $n = 6$. We conclude that the findings of GMP are replicated almost exactly using standing committees instead of ad hoc committees (and all the other procedural differences). Note that there is clear evidence of at least some strategic voting: regardless of treatment, a significant fraction of subjects vote to convict with an innocent signal. In the $n = 3$ cases, the fraction is a bit higher than equilibrium predicts, whereas in $n = 6$, it is lower. In both ad hoc and standing committees, the predicted comparative static, that $\sigma^*(n)$ increases with n, is observed.

Second we ask: Is information aggregation different in ad hoc committees and standing committees? Because standing committees allow greater opportunities for

[11] "Responsive" means that a voter's behavior is not independent of his signal. The GMP study used slightly more informative signals (0.70 compared to 0.67). This results in negligible differences in the equilibrium, $\sigma^*(n)$, as seen in the bottom two rows of Table 1.

	Committee Size = 3		Committee Size = 6	
	Guilty Signal (s = g)	Innocent Signal (s = i)	Guilty Signal (s = g)	Innocent Signal (s = i)
Simultaneous Voting				
Ad Hoc Committee	0.95 (174)	0.36 (186)	0.90 (186)	0.48 (186)
Standing Committee	0.94 (338)	0.35 (382)	0.94 (464)	0.52 (616)
Sequential Voting				
Ad Hoc Committee	0.97 (231)	0.39 (200)	0.93 (317)	0.62 (286)
Standing Committee	0.98 (202)	0.44 (129)	0.98 (287)	0.50 (262)
Symmetric Equilibrium				
p = 0.7	1	0.31	1	0.65
p = 0.67	1	0.32	1	0.66

Figure 1: Frequency of votes to convict by signal (number of observations in parentheses).

coordination, one may conjecture that such committees will aggregate information more efficiently than ad hoc committees. The top part of Table 2 shows the proportion of correct group decisions (convicting the guilty or acquitting the innocent). On the whole, we see at best limited support for this conjecture. In particular, there is virtually no difference in information aggregation between ad hoc and standing committees when $n = 6$. When $n = 3$, ad hoc committees do better than standing committees in the G state, and worse in in the I state: overall, the fraction of correct decisions in the ad hoc committees is 57 percent, whereas it is 64 percent for standing committees. These numbers can be compared with the predictions of the symmetric equilibrium and an efficient equilibrium, i.e. the one that maximizes the committee's welfare, shown in the bottom two rows in Table 2. The efficient equilibrium highlighted in Table 2 is an asymmetric equilibrium where two voters vote informatively (i.e., "vote their signal"), and all remaining voters convict regardless of signal.[12]

[12] For our parameters, an alternative equilibrium in which one voter votes informatively and all remaining voters vote to convict attains the same expected payoffs as the efficient equilibrium we describe in Table 2. In this alternative equilibrium, convictions in the guilty state occur with the same probability as acquittals in the innocent state, a feature not shared by our experimental data in any treatment.

	Committee Size = 3		Committee Size = 6	
	Convicting Guilty	Acquiting Innocent	Convicting Guilty	Acquiting Innocent
Simultaneous Voting				
Ad Hoc Committee	0.47 (57)	0.81 (63)	0.27 (26)	0.97 (34)
Standing Committee	0.39 (132)	0.94 (108)	0.27 (83)	0.99 (97)
Sequential Voting				
Ad Hoc Committee	0.35 (167)	0.79 (106)	0.38 (210)	0.87 (150)
Standing Committee	0.50 (113)	0.78 (97)	0.33 (101)	0.87 (79)
Symmetric Equilibrium				
p = 0.7	0.50	0.86	0.52	0.81
p = 0.67	0.46	0.84	0.48	0.79
Efficient Equilibrium				
p = 0.7	0.49	0.91	0.49	0.91
p = 0.67	0.44	0.89	0.44	0.89

Figure 2: Correct decisions by state (number of observations in parentheses).

II.B Sequential Voting Procedure

We now turn to our sequential voting treatments, where votes are cast publicly one after another. First we ask: Is behavior different between ad hoc committees and standing committees operating under unanimity rule with sequential voting? To address this question, we examine only those observations in which a voter does not already know the outcome of the election, i.e. every preceding voter has voted to convict so far. This is appropriate because once a voter votes to acquit, each subsequent voter is indifferent between voting to convict and voting to acquit.

The bottom part of Table 1 lists the aggregate frequencies with which subjects vote to convict given each signal for such *undecided histories*. This can be compared with the symmetric, history-independent equilibrium of the sequential voting game (bottom row), which simply replicates the symmetric equilibrium of the simultaneous game, an insight due to Dekel and Piccione (2000). The only substantial difference across committee types is in the six person treatments under innocent signals. In this case, subjects in standing committees convict significantly less than in ad hoc committees. In the remaining three cases, there are only small differences ($n = 3$, $s = i$ and $n = 6$, $s = g$) or virtually none ($n = 3$, $s = g$). Overall, at this aggregate level, the behavior of ad hoc committees is closer to the predictions of the symmetric equilibrium.

Second we ask: Is information aggregation different in ad hoc committees and standing committees? Here, we do find some support for the conjecture that standing committees would aggregate information more efficiently than ad hoc committees, although only for the smaller committee size (see Table 2). For the six-person committees, there are only slight differences in the probability of making the right decision conditional on each state. For the three-person case, standing committees appear to do significantly better than ad hoc committees in the G state, but do approximately well in the I state: overall, the fraction of correct decisions in the ad hoc committees is 52 percent, whereas it is 63 percent for standing committees. Again, these aggregate percentages can be compared with the predictions of the symmetric and efficient equilibrium that are listed in the bottom two rows of Table 2.

III Discussion

A remarkable feature of our data is the consistency or robustness across treatments. Recall that the data were collected at various points in time, using different subject pools, software, instructions, etc., and by different experimenters. Yet many features of the data, e.g. the tendency to vote strategically after having received an innocent signal, are similar across treatments, both in qualitative and quantitative terms. Furthermore, we find only minor differences between ad hoc and standing committees, suggesting that repeated interactions do not necessarily lead to the selection of different equilibria.[13]

Interestingly, there are some differences between the simultaneous and sequential

[13] While it would have been desirable to test whether these differences are significant, a challenge that emerges in this context is that observations of group decisions are not independent across rounds. To illustrate, in the standing committee decisions, the past behavior by members of a group may influence a subject's future behavior thereby making the group's decisions across rounds correlated. While the question of significance is important, and one that we hope to address in future work, the remarkable similarity of behavior across treatments suggests that repeated interaction does not lead subjects to use different rules of thumb than one-shot interaction.

treatments that suggest the possibility of information cascades (or momentum effects) under the sequential voting procedure. Consider, for instance, the fraction of correct outcomes for a committee of size six (see the right-most two columns of Table 2). Note that sequential voting results in a higher percentage of convictions in both the innocent and guilty states, possibly because later voters with innocent signals mimicked predecessors who voted to convict.

In future work, we plan to analyze how voting strategies vary with the voter's position under the sequential protocol. In particular, we will compare the history-independent symmetric equilibrium (Dekel and Piccione, 2000) with the history-dependent posterior based voting (PBV) equilibrium proposed by Ali and Kartik (2007).[14] Obviously, in the data there are some deviations that cannot be described by either equilibrium, and we will employ a logit-QRE framework to allow for a maximum likelihood comparison of history-dependent and history-independent voting.

[14] As Dekel and Piccione (2000) have pointed out, in unanimity games, the set of responsive equilibria is identical under sequential and simultaneous voting. Nevertheless, the inherent asymmetry of positions in a sequential procedure may make coordination on some asymmetric equilibria—such as PBV equilibria—more salient. Moreover, we also plan to use majority rule data, where there are sequential voting equilibria that are distinct from any simultaneous voting equilibrium.

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