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Experiments in Political Economy

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1 INTRODUCTION AND OVERVIEW

The biggest challenge to writing a survey about experiments in political economy is answering the question, what is political economy? This being the information age, the natural first step was to google "political economy." This produced the following remarkably broad definitions of the topic.

According to Wikipedia,[1] "Political Economy refers to different, but related, approaches to studying economic and related behaviors, ranging from the combination of economics with other fields, to using different fundamental assumptions which challenge orthodox economic assumptions." The source then goes on to list several completely different subdefinitions of the term, followed by an even longer list of disciplines that relate to political economy: sociology, political science, anthropology, psychology, history, economics, law, human geography, ecology, international relations, cultural studies, and communication.

To narrow things somewhat, the field positive political economy seems to encompass everything (and more) that pertains to laboratory experiments in the economics tradition. It is the title of at least two books and focuses on the kinds of issues and methodologies most familiar to modern-day economists.[2] However, even this does not help much in narrowing the scope of this survey. According to one of the Cambridge University Press Web pages,[3] "Positive Political Economy investigates how observed differences in institutions affect political and economic outcomes in various social, economic, and political systems." If one opens up the book, it turns out to be a collection of essays on various topics in macroeconomics and econometrics. Given that the present volume already includes a chapter on experiments related to macroeconomics, I will exclude that brand of "political economy" experiment from this survey.

Clearly the subject matter, political economy defines an area of study that encompasses several fields of economics, overlaps with several other disciplines, and is also a major field of study by political scientists (Wikipedia's omission from related disciplines notwithstanding).

So, now that we have slightly narrowed the topic, the practical question is where to start and where to stop? First, rather than thinking like an economist and looking at economics experiments that are related to political economy issues, I have chosen the "political" half of political economy as the starting point. There is no chapter in either this or the previous edition of the volume that covers political science experiments. Yet, some of the chapters, most notably the chapter on public goods (Ledyard 1995), cover material that could easily be categorized as political science; some of the seminal contributions in these areas were made by political scientists, explicitly with application to political science in mind.[4]

To make the survey manageable, I have further limited the scope considerably in three ways. First, I have excluded from consideration all nonincentivized experiments in political science and political economy. To give an idea of how much this leaves out, in an earlier volume coauthored with Donald Kinder (Kinder and Palfrey 1993), we devoted fully one-half of the book to nonincentivized experiments and the other half to incentivized experiments, "in the economics tradition." This exclusion is not meant to demean that literature or to suggest that it lies on a lower intellectual plane. It is excluded mainly for compatibility of this chapter with the rest of the chapters of the handbook.[5] Those experiments are in the psychology tradition, and the experiments I will be discussing all fall clearly in the economics tradition, at least methodologically.

Second, I exclude field experiments and economics-style experiments conducted in a field setting, focusing exclusively on controlled laboratory experiments. An obvious reason is that the basic methodology of field experiments is fundamentally different. Neither the degree of control nor the ease of replicability that distinguish laboratory settings is there. These experiments also have the feature that the level of intrusion into the lives of the subjects is much greater than in economics-style experiments,[6] and this raises a different and more complicated set of issues, both logistical and ethical. Another reason why I have excluded field experiments is that I have never conducted any such experiments myself and therefore am qualified to judge the contributions of this work only as an interested outsider rather than a true expert. This reflects a respect for the difficulties inherent in and skills required for field experimentation. Just as someone who has never run an economics or political science experiment in the laboratory is ill-equipped to reliably judge the quality of a paper in that field, someone who has never been involved in a field experiment is poorly equipped to write a survey on it.

Third, I will not include public goods experiments as a special section of this survey. John Ledyard already contributed an excellent chapter to the previous edition, and there is a chapter in the current volume as well. There will be some passing discussion of public goods experiments, however, where appropriate.

This leaves us with a subset of the laboratory research in positive political science, a small bite from the political economy beast.

1.1 Methodology: Relationship to Experimental Economics

This survey also focuses exclusively on experiments that follow the style pioneered in experimental economics several decades ago by by Vernon Smith: *incentivized, controlled, laboratory* experiments. The analogy between this style of political science experimentation and economics experimentation reflects the close intellectual heritage shared by economic theory, formal political theory, and political economy—a heritage whose overlap can be seen in the ideas and seminal contributions of Condorcet, Cournot, and Adam Smith, carrying forward to the more familiar modern contributions of Kenneth Arrow, Duncan Black, William Riker, and others.

The shared connection with rigorous theory is not only due to a long heritage of shared ideas and research questions but is also reflected in the birth of laboratory investigations in economics and political science. The pioneering researchers in the laboratory in both disciplines were trained primarily as theorists who became mainly interested in learning whether the theories were reliable or curious about environments where theory gave little guidance. They turned to laboratory experiments to test theory, in the grand tradition of the physical and natural sciences. In those other disciplines, scientists undertook laboratory experiments, not because there were no field data (indeed field observation is also important in physics, geology, and biology), but because laboratories opened up new questions for which field data were either unavailable or inadequate.

Laboratory experiments in economics designed for theory testing have three key features. First, such experiments create real, but isolated, environments, which operate under a set of institutional rules that are highly controlled and specifically designed to address the research questions of an experimenter. Second, the participants in these experiments are given incentives that are consistent with the theoretical structure of preferences and technology present in the theoretical models. For example, in market experiments the incentives are designed to induce demand and supply functions. Third, an effort is usually made to avoid specific contexts that could confound the incentive structure. For example, in market experiments the participants buy and sell abstract things, as opposed to labeling the items as hair spray, broccoli, or some other real commodity. The predictions of these theories about behavior in the controlled environment were quantified, so the results of the experiment therefore provided a direct test of the theory.[7]

One of the pioneers of political science experiments in the economics tradition is Charles Plott. He conducted early market experiments, as well, to compare the effects of different ways of organizing markets in terms of the detailed rules governing trade and exchange,[8] but his initial forays in the laboratory were in political science in the early 1970s, and the institutional focus of his early experiments had its foundation in social choice theory. Plott had the insight that in principle one could apply induced-value methods to study and compare the effect of different political institutions and voting rules on committee decisions and policy outcomes, although the specific implementation required some innovative techniques. The use of formal theoretical modeling in political science (positive political theory) and social choice theory was developing rapidly at the same time, and these theories were similar to economic theories in the sense that they were deeply rooted in the basic concepts of incentives, rational choice, and equilibrium. The models generated precise quantitative testable predictions about behavior and outcomes in nonmarket settings such as committees, elections, courts, bureaucracies, and legislatures. The nature of institutions being studied is somewhat different in political science than in economics, but both disciplines are concerned with basic questions of resource allocation, mechanism design, efficiency, and distribution. Both have quantitative units of account that determine these allocation decisions. In political science, the score is kept with votes; in economics, the unit of account is monetary. The existence of these quantitative accounting methods in both disciplines naturally lends itself to mathematical analysis. And the rigorous theory developed with such mathematical analysis permits the precise formulation and statement of hypotheses and predictions that are amenable to testing in the laboratory. The quantitative perspective is also useful, as it is in the sciences, to make precise observational statements and measurements (national income, margin of victory, etc.) even in the absence of theory. Pure observation, measurement, and laboratory data together provide the fodder for new theory.

Experimentation using controlled, incentivized, context-free environments naturally followed rather than preceded such research in economics. At the time economists began to design and conduct laboratory experiments with markets and games in the 1950s, rigorous theory as we think of it in economics was virtually nonexistent in political science. The development of a rigorous and quantitative theoretical approach to the study of politics—social choice theory and positive political theory—was virtually a prerequisite for this style of laboratory research in political science. More recently, as research in positive political theory and political applications of game theory is maturing and having an impact in all subfields of political science, the experimental playing field for political scientists is rapidly expanding.

1.2 Chapter Road Map

The focus of this chapter will be on political economy experiments that can be loosely organized around five different categories, and all are tightly linked to formal theoretical modeling in political science. The goal is not to discuss every experimental paper on every topic in political economy (that would require a book), but rather to identify the main insights and tentative conclusions of the most important of these experiments. The frontiers of research in political economy experimentation have been moving rapidly, and this survey will attempt to give a snapshot of this frontier at one point in time. They five topics are (1) committee bargaining, (2) elections and candidate competition, (3) voter turnout, (4) information aggregation in committees, and (5) voting methods that reflect preference intensity.

The pioneering experiments in political economy studied basic principles of committee and voting behavior that had been developed in the axiomatic social choice theory literature in the 1950s and 1960s. The aim was to study the fundamental properties of majority rule and to gather scientific evidence about how actual behavior in committees compared to these abstract theoretical constructs. A key question asked was whether Condorcet winners, when they exist, become the outcomes of committee decision making under majority rule. If so, why? If not, when does it fail and why? The social choice literature was almost entirely normative at the time (1970s), with essentially no empirical component at all.

To scholars well versed in political economy and social choice theory, these questions almost seemed too obvious a point to merit empirical investigation, but they turned to be much more difficult questions to address, including the thorny problem of specifying exactly what it means for a committee to operate under majority rule. There are many possible procedures governing the proposing and seconding of motions, discussion, recognition, amendments, adjournment, and so forth. A complete description of these is a daunting task.[9] Running an experiment to investigate the effect of procedures on outcomes forces the experimenter to define in very precise terms the specific rules that the laboratory committees had to follow. These rules may then be tweaked in subtle ways to address questions of robustness and comparative statics.

This is comparable to the early experiments to study the law of supply and demand in economics, when "competitive markets" were implemented. What does the term *competitive market* mean in terms of the details of how the market is to be organized? For example, is it organized as a double auction or a one-sided auction? Is there a centralized open book or do trades go through a market maker instead? Do trades clear continuously or is it organized as a call market?

In committee experiments there are similar choices to make about majority-rule procedures that had to be faced. What does majority rule mean in terms of the details of committee procedures? How are proposals made? Is there a chair of the committee who has the power of recognition? How can amendments be made? Is there an open or closed rule? Such questions are endless!

Not surprisingly, it turns out that for both kinds of experiments—committee experiments and market experiments—the performance of abstract mathematical theories to predict behavior sometimes worked well and sometimes did not, and this variance in performance depended on both environmental parameters (preferences, feasible alternatives, technology, etc.) and institutional parameters and details.[10] This dependence suggested that the axiomatic theories, which were largely abstracted from institutional details, needed to be reformulated in a way that incorporated such details as procedural rules into the formal theoretical structure in order to obtain empirically valid and robust theoretical results. One could easily argue that laboratory experiments in political economy provided the first noncircumstantial evidence that institutions matter in committee decision making. This evidence was not only noncircumstantial but also had the benefit of being replicable and relatively easy to check for robustness. The theory offered precise comparative static tests about how changing the environment or institution leads to changes in committee outcomes. These effects were causal, because the environment and institutional details in a laboratory experiment are clearly exogenous, unlike, say, comparisons between different political systems based on historical data. This allows for much stronger claims about cause and effect, as opposed to simple correlations between preferences, institutions, and outcomes.

In the next section we discuss experiments coming out of two rather different approaches to the investigation of committee bargaining procedures and decision making. First, we try to clarify the main findings and explore in further detail results from the initial wave of political economy experiments based on axiomatic social choice theory and cooperative game theory. Second, we explore the much more recent experiments on committee bargaining that are designed to test theories from noncooperative game theory. Noncooperative game theory, by specifying the institutional details as rules of a game, often makes more precise predictions about institutional effects than the axiomatic approach. Many of the experiments discussed in later sections, including most political economy experiments of the last two decades, will also be out of the noncooperative game theory tradition. In the next section, the main focus is on noncooperative game-theoretic models of committee decision making in a distributive politics (divide-the-dollar) setting where Condorcet winners do not exist. These are constant-sum games, which are in stark contrast to the earlier focus on nonconstant-sum environments such as the Downs-Hotelling spatial model, where preferences were often specified so that a majority-rule core existed. These noncooperative bargaining models also differ from the axiomatic ones by specifying details of the dynamics and timing of procedures and strategies. The axiomatic models were completely static in nature.

Section 3 explores an important second wave of laboratory experiments in political economy, which followed on the heels of the committee-bargaining studies of majority rule. This second wave was also interested in the empirical properties of majority-rule institutions but focused on competitive elections and candidate competition rather than committee bargaining. There is a range of questions addressed by these electoral competition experiments, and most of these are also central questions that have been studied in more traditional empirical political science. In particular, we focus on the following four topics: retrospective voting; testing the median voter theorem about candidate platform convergence in winner-take-all majority-rule elections; the effect of polls as coordinating devices for voters and information aggregation in elections with more than two candidates; and the effect of candidate quality on candidate divergence.

Section 4 investigates a different set of research questions related to questions of political participation, especially voter turnout. The study of political participation has close theoretical links with related questions about public good provision, free riding, and coordination games. This section will highlight some of the connections between findings in voter-turnout experiments and the insights and regularities from related game theoretic experiments on entry, coordination, and threshold public goods.

Section 5 examines several recent experiments on the effects of voting rules and procedures on information aggregation in committees. For the last decade, there has been a surge of theoretical research addressing questions of efficiency and information aggregation by voting. This new literature has its roots in questions originally posed and analyzed by Condorcet in the eighteenth century and is now commonly referred to as The Condorcet jury problem. Each person in a committee (or electorate) has a piece of information about a true state of the world, and the committee is choosing a decision, where the best decision depends on the state of the world. One can think of this dispersed information as hunches or intuitions or even different interpretations of the same data. From a theoretical analysis based on noncooperative game theory, one can show that different voting rules and procedures can have different information-aggregating properties. For example, different outcomes are predicted under majority and unanimity rules; this varies in surprising ways with the size of the committee and also depends on whether voting takes place simultaneously or sequentially. Most of the laboratory studies of information aggregation look at environments where there is no preference aggregation problem: that is, all voters have the same (state-contingent) preferences but differ only in their information.

Section 6 summarizes results from experiments that examine theoretical models of voting procedures that are explicitly designed for environments where intensity of preference plays an important role. This includes experiments that address traditional questions of interest in political economy, such as logrolling and vote trading, as well as the design and performance of more novel specialized voting procedures such as storable votes and qualitative voting.

2 EXPERIMENTS IN COMMITTEE BARGAINING

This section has two subsections: (1) early experiments from the axiomatic social choice theory tradition, which focus on the core of majority rule games and related concepts from cooperative game theory, and (2) more recent laboratory studies of bargaining in committees with much more structured rules about proposal making and voting—rules that are sufficiently simple to be studied as well-defined extensive-form games.

2.1 Unstructured Committee Bargaining

This line of research, beginning with the landmark article by Fiorina and Plott (1978), explores two distinctly different kinds of questions. First, it tests the basic theory of the core in small committees and examines its robustness with respect to the fine details of committee procedures. The theory tells us that as preferences and/or procedures change in certain ways, outcomes from committee deliberation and decision making should change in corresponding ways. Second, it explores what happens in case the core fails to exist. We know from Plott (1967), McKelvey (1976, 1979) and Schofield (1983) that nonexistence problems are rampant in these environments.

The basic theoretical structure in most of these experiments is the following. The set of feasible alternatives, A, is a convex compact subset of $\Re^2$, usually a square or rectangle.[11] There is a finite set of members of the committee, $I = \{1, \ldots, i, \ldots, n\}$ with Euclidean preferences, where n is an odd number for most experiments. Therefore the environment is fully specified by $[A, I, x]$, where $x = (x^1, \ldots, x^i, \ldots, x^n) \subseteq A^n$ is the profile of members' ideal points. For any such environment, we can define the simple majority rule binary relation. For any pair of alternatives, $a, b \in A$, we write $a \succ b$ if a majority of the members of I strictly prefer a to b. In this case, we say a defeats b under majority rule. If a does not defeat b, we write $b \succeq a$. The majority rule core, or the set of Condorcet winners, $C \subseteq A$, includes precisely those alternatives that are undefeated under majority rule. That is $C = \{c \in A \mid c \succeq a \; \forall a \in A\}$. An implication of the results in Plott (1967) is that in these environments, if n is odd and the x^i are all distinct, then (1) the core coincides with one of the member's ideal points, call it x^{i^*} and (2) the other members can be paired up in such a way that for each pair, the line connecting the ideal points of the pair pass through x^{i^*}. The condition is sometimes referred to as pairwise symmetry and has a natural generalization to environments with arbitrary quasi-concave and continuous preferences with ideal points in terms of pairs of utility gradients at the core point.

2.1.1 Majority-rule Core Experiments

Fiorina and Plott (1978) created sixty-five five-member laboratory committees, each of which deliberated under a simplified version of *Roberts' Rules*. The policy space included a fine grid of points in a two-dimensional policy space. The two dimensions in the model correspond to policy choices, such as spending on defense and tax rates, but no labels as such were used in the experiments in order to maintain a neutral context. The policy space was, literally, the blackboard. The preferences of the members were induced using monetary payments that depended on the outcome and differed across subjects. For each subject, the iso-payment contours coincided with their indifference contours in the theoretical model, either concentric circles or ellipses, so this method was an innovative extension of the induced value approach to political environments, where voter preferences are characterized by quasi-concave utility functions in a multidimensional Euclidean space with unique ideal points. Figure 6.1 illustrates an example of a voter's payoff function and indifference curves in the policy space.

Deliberation was moderated by the experimenter, according to the following procedure. The deliberation by each committee started at a status quo point that generated low payoffs for all members. At any time, a member could raise his or her hand and propose an alternative point; a vote between the status quo and the alternative ensued, with the alternative becoming the new status quo point if it passed by receiving a majority of votes. This could continue indefinitely, as long as members made new proposals. At any point, a member could propose to adjourn the meeting. If the motion to adjourn received a majority of votes, then the session ended and subjects were paid based on the last alternative that had passed (or the original status quo, if no alternative ever passed). The main treatment variable in the initial experiment was the preference profile, using two preference profiles for which a core existed (series 1 and series 2) and one where a core did not exist (series 3).[12] Figure 6.2 shows the distribution of ideal

Figure 6.1: Sample indifference map. *Source*: Fiorina and Plott (1978).

points for one of the five person committees where a core point exists, where voters have elliptical indifference curves. Alternative predictions are labeled by the letters *A*, *B*, and *C*. *A* is the core point and also coincides with several other solution concepts examined in the paper, such as the von Neumann–Morgenstern solution. *B* corresponds to what would be the Condorcet winner if voters acted as if they had city-block preferences. The two *C* points are dimension-by-dimension medians.[13]

In the series 3 preference profile, where a core point did not exist, the ideal point of i^* voter in series 1 was shifted a small distance, breaking pairwise symmetry. Thus, this treatment was designed to test whether the discontinuous nature of core existence would lead to a discontinuous change in committee outcomes. It was an important variation

Figure 6.2: Series 2 preference configuration.

to investigate, since results by McKelvey on global cycling (or "chaos") were widely interpreted at the time as implying anything can happen in the absence of a core point.

Figure 6.3 shows the distribution of outcomes in the series 2 (top panel) and series 3 (bottom panel) committees. Series 3 voters had circular indifference curves with their ideal points indicated in the figure.[14] In Series 2, three out of the ten committee outcomes were exactly at the majority-rule core point of (61, 69), and the mean outcome was (60, 72).[15] The series 3 outcomes show a remarkable central tendency, with a variance of outcomes less than half of what was observed in the low-payoff series 1 committees.

Principal Findings

1. *Core Clustering.* When it exists, the core is the best predictor among sixteen competing hypotheses to explain committee outcomes. While few outcomes are exactly at the core point, the outcomes tend to cluster nearby the core point, when it exists.
2. *Robustness.* The secondary treatments had little effect, although there was greater variance of outcomes when payoff magnitudes were low (low incentives).
3. *Continuity.* When the core point did not exist, but the preference profile was close to admitting a core point, the outcomes still clustered around a region in the policy space in much the same way as was observed when a core point existed! Thus it appears that the distribution of committee outcomes varies continuously with the preference profile of the members.

The third of these observations is perhaps the most important. Why? The theory of the core is not a behavioral theory but simply a property of the majority-rule binary

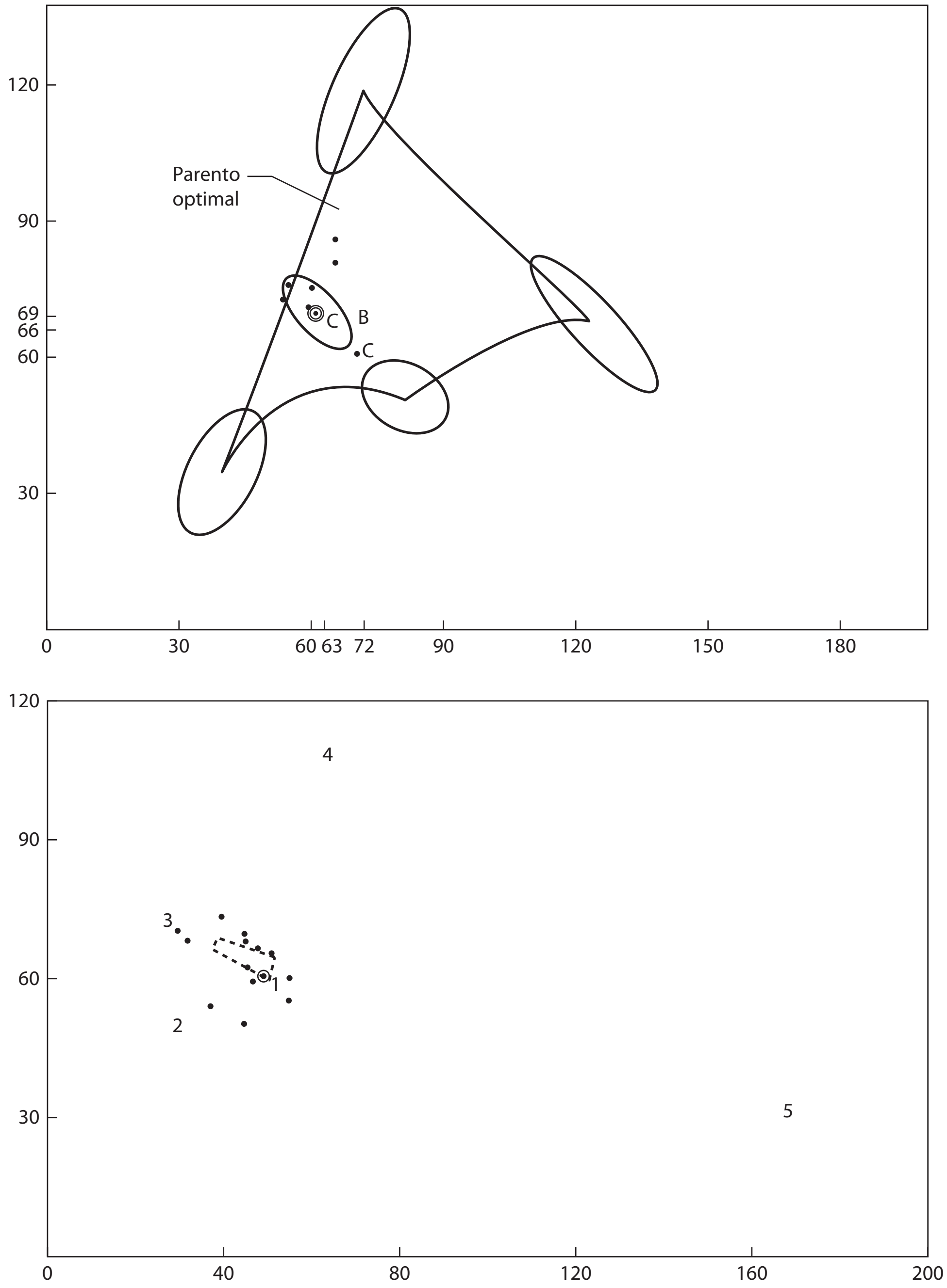

Figure 6.3: Outcomes in series 2 (*top panel*) and series 3 (*bottom panel*) committees.

relation. The deliberation procedure, while simple to describe, is virtually impossible to model as an extensive form game. There is no theory of who makes proposals, no theory of how people vote on proposals, no theory of adjournment, and so forth. That is, Fiorina and Plott (1978) and subsequent studies along the same line investigate environments and procedures for which there is no accepted behavioral model to describe or predict individual actions. These are experiments that test both axiomatic theories of social choice as well as ad hoc behavioral theories.[16]

2.1.2 The Robustness of Core Clustering

With few exceptions, subsequent research has reinforced most of the preceding conclusions. Berl and others (1976) investigate some variations on the original Fiorina and Plott (1978) study[17] and find, among other things, that experimenter participation in the committee was inconsequential. Furthermore, the results were robust to additional variation in non-Euclidean preferences (using city-block metric preferences). A later study by McKelvey and Ordeshook (1984a), restricts agendas to issue-by-issue voting and finds that outcomes still cluster around the core. This, together with the findings about limitations on debate/communication, illustrate how robust core clustering is with respect to significant procedural variation.[18]

Rick Wilson and his coauthors have conducted a range of different variations on Fiorina and Plott. One of the more interesting extensions is to assess everyone on the committee a fixed cost (called an agenda access cost) whenever a proposal is successful (Herzberg and Wilson 1991). This has two interesting and countervailing effects. First, it expands the set of core outcomes. For example, in the Fiorina and Plott environment without a core, a core point exists even with rather small access costs. The second effect is more subtle. Because changes are costly, members are more reluctant to vote for any change, and this creates a drag on the process. Voters might even vote against a change that makes them better off in the short run because they fear the change will lead to further changes that will impose additional costs. The findings, therefore, are mixed, reflecting the ambiguity of the theory. For example, if a core already exists in the absence of access costs, the experimental results show that imposing access costs leads to more dispersion in the final outcomes, a negative effect. Outcomes still cluster near the core but with more scatter, and occasionally the process fails entirely, without ever moving away from the initial (bad) status quo. These experiments are particularly instructive because they suggest other factors affecting individual behavior, such as risk aversion, and also suggest that subjects were not myopic in their voting decisions but anticipate the future consequences of current votes.

Plott conducted some additional experiments showing that the results replicate to larger committees[19] and also for committees where there was agenda control by one or more of its members. In Kormendi and Plott (1982), one member of a five-member committee serves as a gatekeeper (called a convener in the paper), who was allowed to offer or unilaterally block proposals in an environment with the same preferences as one of the Fiorina and Plott core treatments. This agenda power restriction changes the core, since blocking coalitions must include the agenda setter. The core expands and becomes the line segment between the original core point and the agenda setter's ideal point. They run one treatment with one agenda setter and another with a second agenda setter, and the outcomes in both cases line up closely with the core (set) predictions. Hence these experiments show that the majority-rule core, modified to account for changes in proposal procedures, continues to predict committee outcomes. The important corollary is that subtle changes in procedures can cause dramatic changes in outcomes, exactly as predicted by cooperative game theory.

There are some exceptions to the robustness of core clustering. One of the more striking results is from an experiment by Eavey and Miller (1984a), which follows up on an earlier experiment by Isaac and Plott (1978) and is not in a spatial setting.[20] Isaac and Plott looked at three-person committees with a convener, but with an abstract finite set of possible outcomes, so the environment was not framed to the subjects as a two-dimensional policy space. There is a unique core, which predicts outcomes very well. Eavey and Miller point out that the core in that experiment was also a fair outcome that gives a reasonable payoff to everyone. They design a "critical" experiment in which the fair outcome is different from the core and both are unique. They find that the fair outcome was selected eight out of ten times, and the core was selected only twice. The results with five-person committees were similar, but there was a bit more scatter in the data. Eavey and Miller conclude that interpersonal comparisons (fairness, altruism, universalism) are relevant consideration in outcomes, especially for very small committees.

Salant and Goodstein (1990) propose a solution concept that predicts *sets* of outcomes rather than specific outcomes and argue that their alternative approach can explain both the phenomenon of core clustering in spatial models and the apparently contradictory findings of Eavey and Miller in abstract finite policy spaces. They point out that in the abstract policy spaces, there is no natural metric for closeness between alternatives, and therefore one cannot address the question of whether outcomes are far or close to the core outcomes. In other words, the notion of core clustering as applied to spatial committees is not a general concept that can be applied to any committee setting. Their main insight is that the solution concept of the core is based purely on the ordinal preferences of the committee members, but outcomes of committee experiments clearly depend on the *cardinal* preferences of the members. This was apparent from the very first experiments by Fiorina and Plott, where they found more core clustering (less scatter) in their high-payoff committees than in their low-payoff committees. The concept of fairness invoked by Eavey and Miller implicitly use some notion of cardinality or at least interpersonal comparison of utility.

The Salant and Goodstein *selection set* is based on payoff thresholds and has a motivation similar to epsilon equilibrium. Committee members are assumed to have a threshold payoff difference, such that they are insensitive to payoff differences less than that threshold. Loosely speaking, given a threshold t, an outcome, x is t-blocked if there is a coalition, C, consisting of a majority of members and an an alternative y such that the payoff difference between y and x is greater than t for all members of the coalition. Therefore, the larger is t the larger is the selection set (i.e., t-$stable$ outcomes). For $t = 0$, only core outcomes are stable. For t sufficiently large, all outcomes are stable. Also note that for a fixed t, if the payoffs of all members are scaled up (as in the Fiorina-Plott high-payoff treatment), the selection set shrinks. They then conduct their own experiment[21] and estimate t from their data. Using this estimate, $\widehat{t}$, they reexamine data from a number of earlier experiments, including Fiorina-Plott and Eavey-Miller, and ask whether the outcomes in those experiments are in the selection set for $\widehat{t}$. They find that their theory postdicts very well out of sample. In fact, for the Eavey-Miller experiments, the only two $\widehat{t}$-stable outcomes are the core and the "fair" outcome. This suggests a completely different interpretation of the Eavey-Miller results that has nothing to do with concerns about equality or fairness.

2.1.3 Continuity and Experiments with an Empty Core

A large number of experiments followed up on Fiorina and Plott by exploring preference configurations where a core does not exist. One reason for doing so was to investigate the predictive value of alternative models based on cooperative game theory, such as the von Neumann–Morganstern set (V-set) and various incarnations of the bargaining set. Unfortunately, these alternative models from cooperative game theory were not particularly successful in explaining the data across these different experiments. They also had additional weaknesses, including existence problems (not as severe as the core but problematic nonetheless), and also a failure to predict the actual winning coalitions that might form and how these coalitions depended on the winning outcomes in a committee. Motivated by a desire to overcome these drawbacks and develop a general predictive theory for these committee games, McKelvey and others (1978) developed "the competitive solution" for N-person simple games without side payments. The concept was based on the notion of pivotal coalition members. In order for a winning coalition to hold together, they suppose that the coalition must bid for its membership in the sense of supporting an alternative that makes its members at least as well off as the alternatives (implicitly, the bids) by all other minimum winning coalitions each member could join. In the competitive solution, some members will be pivotal in the sense that the bids by different winning coalitions make them exactly indifferent between which coalition to join. Thus the competitive solution implicitly selects both outcomes and (minimum winning) voting coalitions.

Unlike the later work by Salant and Goodstein, the competitive solution does not depend on cardinal information about preferences to make predictions about outcomes in committee bargaining voting. McKelvey and others (1978) conduct several experiments and show that in spatial voting environments the competitive solution fares pretty well.[22] However, McKelvey and Ordeshook (1983) report a subsequent experiment in a nonspatial finite alternative environment where the competitive solution is clearly rejected. Consistent with some other findings discussed in this section, part of the source of the rejection is due to the fact that cardinality of preferences appears to play a role.[23]

A Fourth Principal Finding This leads to a fourth principal finding from this large class of committee voting experiments:

4. *Cardinality of preferences matter.*[24] Solution concepts that depend only on ordinal preferences over policies will generally fail to account for variation of committee outcomes across different cardinal utility profiles.[25]

2.2 Committee Bargaining with a Fixed Extensive Form Structure

2.2.1 Agenda-control Experiments

A landmark paper by Romer and Rosenthal (1978) set the stage in political science for a wave of theoretical work that looked at the power of agenda setters when bargaining in the shadow of an unpopular status quo. The main idea is illustrated in its starkest terms by the example of Niskanen (1971), where a budget maximizing the agenda setter has the power to propose a budget that must pass some voting body by majority rule. If it fails, the status quo budget is 0. Suppose that all voters have Euclidean preferences so that utility declines symmetrically to the left and right of a voter's ideal budget, and suppose the median voter has an ideal budget equal to $B > 0$. Then the win set (i.e., the set of proposals that will pass) is the interval $[0, 2B]$. Hence the unique subgame perfect-equilibrium outcome of the two-stage game where the setter proposes a budget B_p in stage 1 and the vote is taken between 0 and B_p in stage 2 is $2B$. Every voter to the left of the median voter votes no, and everyone to the right of (and including) the median voter votes yes. If we think in terms of bargaining theory, this is a not-so-transparent variation on the very closely related ultimatum game. In fact, it really is just a two-person game between the agenda setter (proposer) and the median voter (responder). As in the ultimatum game, the responder gets nothing and is indifferent between rejecting the offer and accepting it. Romer and Rosenthal extend this idea to a more general setting in a one-dimensional spatial model and an arbitrary status quo and an arbitrary ideal point of the setter. As long as the setter's ideal point and the status quo are on opposite sides of the median voter's ideal point, the setter has bargaining power and is able to pass a proposal that is closer to his or her ideal point than the median outcome would be if he or she did not have the power to set the agenda.[26]

Eavey and Miller (1984c) conducted an experiment to test the predictions of this agenda-setter model. Their design can be thought of as a modification of the convener design discussed before, but they ran a number of different variations on procedures and the way the alternatives and preferences were explained to the subjects. In their strong agenda-power treatment, the proposer can make only one single take-it-or-leave-it offer: if the proposal fails, then the experiment is over and a predetermined status quo is implemented. This creates a well-defined two-stage extensive form game. The subgame perfect equilibrium is for the convener to propose the alternative he or she prefers most, among those proposals that at least a majority (weakly) prefers (under the induced monetary payoffs) to the status quo. The proposal should always pass, according to the theory, and the median voter is indifferent between the proposal and the status quo.[27] They also had a weak agenda-setter treatment when the agenda setter could offer alternatives multiple times. That is, they could not commit not to recontract if a proposal failed. Finally, they had a baseline open-agenda treatment where the agenda setter had no power at all.

Eavey and Miller had a couple of different implementations of the setter game. In one, they used an environment with a small number of alternatives, as in Isaac and Plott (1978); in the other, there is a one-dimensional policy space with single-peaked preferences. The two settings however, were essentially isomorphic, although the spatial context allowed for a finer set of feasible alternatives. In all experiments, the convener has complete information about the preferences of the voters (cardinal payoffs as well as ordinal payoffs), but the voters only know their own payoffs and are given absolutely no information about the payoffs of the other voters or the convener.

The first finding, more or less a replication of past experiments, was the frequency of core (median) outcomes with an open agenda. In both the weak and strong agenda-setter treatments, they observe nonmedian outcomes favoring the agenda setter, a qualitative prediction of the setter model. However, the magnitude of the agenda-setter effect is less than the subgame perfect equilibrium of the model. Setters do not make proposals that would fully exploit the other voters, assuming those voters are simply maximizing their payoff in the experiment. Rather, setters offer proposals giving other committee members significantly higher payoff outcomes than are predicted in the subgame perfect equilibrium. They also find no difference between the strong and weak agenda control protocols.[28] One conjecture is that this is due to the way they implemented the game. Rather than simply playing a simple two-stage game as in standard ultimatum-game experiments, extensive discussion and haggling were allowed to take place during the experiment. This would allow coalition formation to arise among the voters and also allowed personality factors, including how articulate or persuasive the convener is, to affect the outcomes. The article includes snippets of the discussion, which clearly show the importance of haggling and persuasion. Furthermore, none of the subjects had an opportunity to become experienced in the task (as was usual practice in these old committee experiments). To this author's knowledge, nobody has ever gone back and tried to replicate these experiments with a protocol closer to now-accepted common practices in experimental (noncooperative) game theory.[29] Given the strategic similarity between two-person ultimatum games and the setter model, a reasonable hypothesis is that the findings of Eavey and Miller (1984a)—that proposers are able to partly but not fully exploit their favorable bargaining position—reflect essentially the same phenomenon as in ultimatum games, but with more than two players. Interestingly, while the setter experiment and the first ultimatum game experiments were conducted independently and essentially at the same time, neither group of researchers were aware either of the other experiments or even the existence of other closely related models.

Lupia (1994) also studies a variation of the setter model to explore the effect of incomplete information by voters about the exact location of the setter's proposal. The complete information baseline treatment more or less confirms earlier findings. The setter is able to exploit his or her agenda power but is unable to fully extract all rents from the median voter.[30] In the main incomplete information treatment, the voters do not observe either the setter's ideal point or the proposed policy. However, the setter must pay a cost to make the proposal, so in equilibrium voters can infer something about the setter's ideal point simply from observing whether or not he makes a proposal. The voting behavior in this signaling experiment is consistent with the hypothesis that voters often make correct inferences from the setter's decision to make a proposal.

Principal Findings

1. In agenda-control experiments, the setter or convener is able to exploit her power, leading to outcomes that give her greater utility than the majority rule core outcome.
2. Agenda setters or conveners are usually not able to fully exploit their agenda power.
3. Findings are similar to results from alternating offer bargaining games, such as the ultimatum game.

2.2.2 Voting Over Fixed Agendas

There is an extensive theoretical literature on voting over fixed agendas. Some of the most general and insightful results concern a certain kind of strategic voting, usually referred to as *sophisticated voting*, and the predictions about the set of possible equilibrium outcomes under sequential *binary amendment agendas*. A sequential binary amendment agenda procedure can be represented as a sequence of n alternatives in some policy space X, denoted $(x_1, \ldots, x_n)$. In such a procedure, there is first a pairwise vote taken between x_1 and x_2. Then the committee votes between the winner and x_3, and so on. Finally, the last vote is between the winner of the $n-1$ vote and x_n. Thus, in set notation, one can represent the first vote as being between $\{x_1, x_3, \ldots, x_n\}$ and $\{x_2, x_3, \ldots, x_n\}$. If x_2 defeats x_1 in the first round, then the second round vote can be represented as being between $\{x_2, x_4, \ldots, x_n\}$ and $\{x_3, x_4, \ldots, x_n\}$, and so forth. These games are dominance solvable (McKelvey and Niemi 1978) and the sophisticated (backward-induction) outcomes are uniquely defined if preferences over X are strict and there is an odd number of voters.[31]

The sophisticated outcomes (i.e., outcomes when everyone votes sophisticatedly) can differ, sometimes dramatically, from the outcomes that would arise if everyone simply voted *myopically*, or *naively*, that is, if everyone voted at each stage as if it were the last stage. The classic example of this is based on the so-called Condorcet cycle for majority rule voting, where there are three voters $\{1, 2, 3\}$ and three alternatives $\{A, B, C\}$. Voter 1 has preferences $A > B > C$, voter 2 has preferences $B > C > A$, and voter 3 has preferences $C > A > B$. This results in a majority-rule cycle, with $A >_m B >_m C >_m A$, where $>_m$ denotes the strict majority binary relation. The existence of such a cycle implies that sophisticated voting will lead to different outcomes than "naive" voting in a two-stage agenda. Consider the sequential binary agenda, (A, B, C), where in the first stage A is voted against B and in the second stage the winner of the first stage is voted against C. Then, working from the end, the last stage outcome will be B if B is the first-round winner and C if A is the first-round winner. Therefore, with sophisticated voting, the vote in the first round is treated as, in effect, a vote between B and C rather than the literal vote between A and C. Thus, voter 1 will vote for B in the first stage, even though his or her naive or myopic preference is to vote for A. For the other two voters, their myopic and sophisticated voting strategies coincide. Thus, the sophisticated outcome here is B, while the outcome would be C if everyone voted myopically.

Like finite alternating offer bargaining and other simple extensive form games in economics, agenda-setting games are natural candidates for studying behavioral issues of subgame perfection, dominance solvability, strategic sophistication, and equilibrium. Also like bargaining games, the theoretical results have shaped the way scholars in the field approach applied questions (such as agenda influence in the legislatures), and, therefore, careful testing of the theory of sophisticated voting over binary agendas has the potential for significant impact.

The initial experiments related to sophisticated voting are reported in Levine and Plott (1977), Plott and Levine (1978), and Cohen, Levine, and Plott (1978) and used much more complicated agendas than the simple example given before. While the agendas they explore are more general than the binary amendment procedure, the basic ideas of backward induction, dominance, and sophisticated voting can be applied directly because every vote involves a binary choice between subsets of feasible alternatives, and the agendas are *determinate* in the sense that the terminal nodes of the voting tree are all associated with unique feasible outcomes. There is one important difference in these early experiments: voters had information only about their own preferences over the alternatives, so these were games of incomplete information. However, extensive discussion was an important component of the committee decision-making procedures, and voters had an opportunity to communicate their preferences to other voters. Thus, while perhaps dubious as an equilibrium prediction for these environments, the sophisticated voting outcome is a natural benchmark.

Here is an example of the kind of agenda they consider, which one might call a *divide-the-question agenda*. Suppose three economists are trying to decide to which restaurant to go, and there are four possibilities: one is expensive and serves Italian food (EI), one is cheap and serves American food (CA), one is cheap and serves Italian food (CI), and the fourth is expensive and serves American food (EA). The restaurants differ along two different dimensions, and one can consider "dividing the question" by voting first on one dimension (E vs. C) and next on the second dimension (A vs. I). This is equivalent to a two-stage agenda where the first vote is between the sets $\{EI, EA\}$ and $\{CI, CA\}$ and the second stage is a vote between the two alternatives of the pair that won in the first round. Note that this is not equivalent to

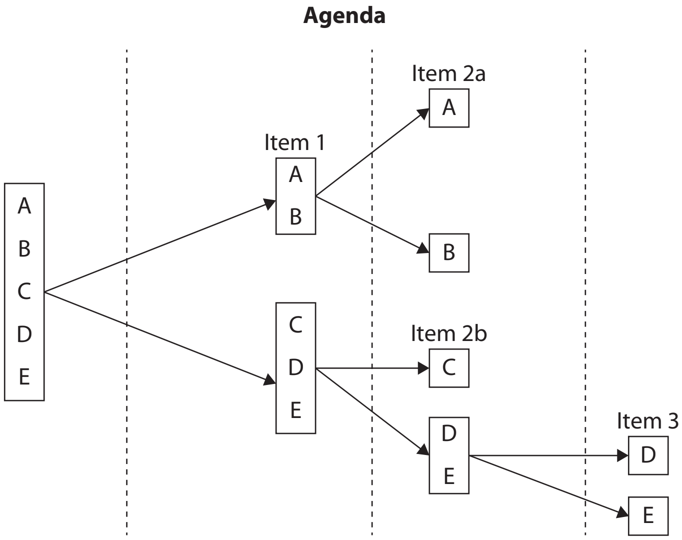

Figure 6.4: Sample agenda. *Source*: Plott and Levine (1978).

a binary amendment procedure. For example, a binary amendment procedure with the alternatives ordered $\{EI, EA, CI, CA\}$ would imply a three-stage agenda, where (in set notation), the first vote is between $\{EI, CI, CA\}$ and $\{EA, CI, CA\}$, and so forth. In all agendas considered in these three papers, all players have strict preferences, and there is an odd number of voters, so if one analyzes the games as if the players had complete information about ordinal preferences over the alternative set, then the games are dominance solvable by the Farquharson-Niemi-McKelvey sophisticated voting algorithm.

The experiments were conducted with two RAs in the room, one to chair the discussion and another to record the proceedings. Discussion was limited in several ways: promises of side payments were not allowed; threats were not permitted; subjects could only make qualitative statements about their preferences, not quantitative statements about their exact payoffs from different alternatives; and straw votes "down the agenda" were not permitted. There were twenty-one different voters in the committee, which had to decide which one of five possible alternatives, $\{A, B, C, D, E\}$, to select via a majority-rule agenda. The preference orders of the twenty-one voters implied a majority rule relation in which A was a Condorcet winner, E was a Condorcet loser,[32] and the middle three alternatives cycled: $B >_m C >_m D >_m B$. They conduct a number of three-stage agendas, an example of which is shown in Figure 6.4.

Under sophisticated voting, A should be the outcome in all agendas. In the agenda illustrated in Figure 6.4, for example, the first stage is a vote between $\{A, B\}$ and $\{C, D, E\}$. If the outcome is $\{A, B\}$, then a final vote is conducted between A and B. If the outcome is $\{C, D, E\}$, then a vote is conducted between $\{D, E\}$ and $\{C\}$, with a final third stage needed only if the outcome of the second stage is $\{D, E\}$. Working from the last stage back to the beginning of the agenda, it is easy to see that the sophisticated equivalent of $\{D, E\}$ is D, and hence the sophisticated equivalent of $\{C, D, E\}$ is C. The sophisticated equivalent of $\{A, B\}$ is A. Therefore $\{A, B\}$ defeats $\{C, D, E\}$ in the first stage under sophisticated voting; then A defeats B in the second stage. The other agendas in the paper are solved by similar logic.

The design of the experiments and the analysis of the data was not motivated by a desire to test the Farquharson-McKelvey-Niemi theory of rational sophisticated voting.[33] Indeed the game-theoretic predictions are barely alluded to in the paper. Instead they propose a mixture of types model where there are three different possible behavioral decision rules. The first decision rule is called *sincere voting*. Because sincere voting is not well defined over subsets, they define it as simply voting between the top (i.e., most preferred) elements of the two subsets. Hence this decision rule can be thought of as "optimistic," or hope-for-the-best, behavior. The second decision rule is the exact opposite, where players behave pessimistically; it is called the *avoid-the-worst* decision rule. In this case a voter would compare the least preferred alternative from each subset and vote for whichever set has the better worst alternative. The third decision rule strikes a balance between the optimistic and pessimistic rules and is called the *average-value* decision rule. In this case, the individual evaluates each subset, in terms of the expected utility of a uniformly distributed lottery over the alternatives in the subset and votes for the subset with the highest expected utility under this assumption. Thus, unlike the first two decision rules, the average-value decision rule depends on more than just the ordinal ranking of the (pure) alternatives. Individuals are then considered to be random variables with respect to following one of these three decision rules, and the theory is fleshed out with a number of parameters governing the relative frequency of these decision rules in the subject population.

The authors first conducted several pilot studies that are not reported in the paper. The main value of the pilot studies, in addition to fine-tuning the instructions and procedures, is that the data from those studies could be used to estimate the parameters of their decision rule model. Using these parameters, they design the agendas used in the experiment reported in the paper (series 4 data). In most of these agendas, the sophisticated outcome was different from the predicted outcome based on their model. Except for only one agenda, their model was generally successful. In the single agenda where the model failed to correctly predict the outcome, the outcome achieved by the committee was the sophisticated outcome (and the Condorcet winner).[34] That committee was the only committee that was allowed to conduct a down-the-agenda straw vote, which essentially converted the agenda voting game to one of complete information.

These results are not easy to interpret. Clearly they are not a rejection of sophisticated voting theory, which either implicitly or explicitly requires complete information (or nearly complete information) in order for the dominance solvability argument to make any sense. In these experiments, voters had only private information about their own preferences and were not even given probabilistic information about other members' preferences. It is really an environment with decision making under conditions of (nearly) complete ignorance. Thus it is not surprising that the data can be mostly explained in terms of theories of decision making under ignorance, such as the principles of insufficient reason (decision rule 3) or maximin (decision rule 2). The allowance for discussion was apparently insufficient to produce meaningful information transmission, with the one exception arising when the discussion was allowed to include straw votes.

The Levine-Plott (1977) paper reports a similar exercise in predicting agenda outcomes from a field application of the agenda model. The authors belonged to a flying club that was deciding on the composition of a new fleet of planes. There were many possible options, and the authors were asked by the club to devise an orderly voting procedure to produce an outcome. The authors obtained rough preference information from the other members via discussion at earlier meetings and personal knowledge of the other members[35] and then applied their model to construct an agenda designed to produce one particular outcome.[36] Indeed, the agenda did succeed in producing the targeted outcome, even though one of the other options was a Condorcet winner. Cohen, Levine, and Plott (1978) report the results of some further series of divide-the-question agenda experiments and results that are mostly in line with the findings of Levine and Plott (1977) and Plott and Levine (1978).

There have been only three subsequent experiments to study sophisticated voting with fixed binary agendas. Herzberg and Wilson (1988) note that the lack of support for sophisticated voting in the earlier studies was probably at least partly due to the difficulty or impossibility of calculating optimal sophisticated strategies because preferences were not common knowledge. Besides this, even if preferences were common knowledge, the strategies used by other voters may be difficult to predict as well. Furthermore, all these difficulties would presumably be even more difficult in longer agendas. In an attempt to create a laboratory environment that minimized these informational complexities, they consider small five-voter committees, in which only one of the voters is a human subject. The remaining voters are computerized and subjects are provided with sufficient information to infer exactly how the computers will vote at each stage of the agenda.[37]

There are two main findings. First, the hypothesized relationship between agenda complexity (measured by agenda length and number of feasible alternatives) finds little support in the data. The six-alternative agenda has the highest frequency of sophisticated outcomes. More supportive of this hypothesis is the finding that longer agendas produce more "stray" outcomes (i.e., neither sophisticated voting outcomes nor sincere voting outcomes). Second, sincere voting outcomes occur more frequently than sophisticated voting outcomes in all three agendas. The agendas are all fairly long, as there are either four, six, or eight alternatives and the agendas are, respectively, three, five, and seven stages long. Like the agenda experiments described earlier, subjects are naive and inexperienced, vote over only one of the agendas, and play that game exactly once.[38]

The paper leaves open a number of questions about both design (e.g., the use of sincere computerized voters and inexperienced human voters) and substance (e.g., how voters formulate their voting strategies in an agenda under conditions of complete information). Regarding the latter, there are many findings from bargaining games[39] and other multistage games[40] where players have to make multiple sequential decisions and do not follow backward-induction solutions. This is true even in cases where the backward induction solution is efficient and perfectly equitable (Fey, McKelvey, and Palfrey 1996), although with repetition there is convergence in the direction of the backward-induction solution.[41] There is also a concern about the use of computerized subjects and the possibility that telling subjects the computers vote sincerely may lead subjects to adopt a similar rule of thumb.

Eckel and Holt (1989) take a somewhat different avenue to extend these earlier findings. In particular, they choose to look at extremely simple two-stage agendas and run different treatments that combine and extend some of the features of the Plott and others' and Herzberg-Wilson studies. First, they run sessions both with complete preference information and with private information. Second, they repeat the task for the subjects ten times. They have a second treatment concerning how often the preference assignments were changed during the ten rounds. In one case (call it random), they are changed every round, and in the other case (call it fixed), they remain unchanged until the sophisticated voting outcome is achieved, at which point they change. In the latter case, subjects are not informed about the rule for changing assignments. For the private-information treatments, partial leakage of this private information can take place in two ways: a restricted form of prevote discussion similar to the Plott and others' procedures is allowed; through task repetition voters have an opportunity to learn how to forecast voting behavior in the second stage of the agenda.[42]

In all their sessions, there were three alternatives, $\{A, B, C\}$, and three preference types, $A > C > B$, $C > B > A$, and $B > A > C$, so the preference profile produced a majority-rule cycle. There were nine subjects and three of each preference type, and eight sessions were conducted. The two-stage agenda was always first to vote between alternatives A and C and second to vote the winner of the first stage against B. The only difference between sophisticated and sincere voting arises in the first round, where the three $A > C > B$ voters should vote for C because B will defeat A in the second round (6 to 3), but C defeats B. A clever aspect of their design is that all three of the Plott and others' decision rules (sincere, avoid-the-worst, and average-value) predict sincere voting by all types at both stages. This provides a very clean test of the decision-type mixture model, against a clear alternative hypothesis: sophisticated voting. There are three main findings. First, *repetition is necessary and sufficient* for the committees to converge to the sophisticated voting outcomes. In all eight sessions, not one single subject (i.e., zero out of twenty-four) voted sophisticatedly on the first meeting (play of the game). Across the five sessions using the "fixed" preference assignments there are ten subsequences where the preferences are the same in at least two consecutive rounds. In *all* ten cases, the committees converge to the sophisticated outcome regardless of whether the preference profiles are public or private information. Second, the *fixed* repetition protocol is *not* a necessary condition for sophisticated outcomes to obtain, but it is considerably more difficult with random repetition, and such outcomes are only observed in the public information treatments. In particular, the proportion of voters who vote sophisticatedly is significantly less with random repetition compared to fixed repetition.[43] Third, there are significant differences across individuals. Some subjects learn to vote sophisticatedly and some do not. While sophisticated voting becomes widespread with fixed repetition, it is by no means universal.

Principal Findings

1. If voters have little or no information about other voter's preferences, they do not behave according to the backward induction logic of sophisticated voting. Instead, their behavior is best described by a combination of simple rules of thumb for decision making under complete ignorance.
2. If voters have an opportunity to learn about the preferences of other voters, behavior is largely consistent with sophisticated voting, at least in relatively simple agendas.

2.2.3 Dynamic Bargaining in the Shadow of a Voting Rule

The Baron-Ferejohn (BF) Bargaining Model The Baron-Ferejohn (1989) bargaining model is a blend between the Rubinstein-Stahl bargaining game and the Romer-Rosenthal monopoly agenda-setter model. The Romer-Rosenthal setter model is the political science version of the ultimatum game but in a political model with single peaked preferences and a voting rule. The Rubinstein-Stahl bargaining model is the infinite-horizon limit of alternating offer games, of which the ultimatum game is the shortest possible. In Romer-Rosenthal, the game ends with a status quo outcome if the setter's proposal is voted down.[44] But in models of the BF tradition, the process of offer and accept/reject may continue indefinitely, with the proposer typically changing over time in the event the proposal is rejected. In this repeated version of bargaining, a much richer set of strategic possibilities emerge.

In the setter model, there are four critical factors that determine the equilibrium: the set of feasible alternatives, the policy preferences of the setter, the voting rule, and the policy preferences of the voter who is pivotal under that voting rule. In moving from the one-shot setting to a repeated version of committee bargaining, some additional structure is required to capture several new factors that come into play. These additional factors include the time preferences of the voters, the recognition rule that determines the proposer at each stage as a function of the history of play, and the amendment procedure.

The "standard" BF model is limited to purely redistributive policy spaces. In the simplest version of the model, a committee of size n (odd) must decide how to divide a dollar among its members. One of the members is selected at random (recognized) to propose a division, $d_1 = (d_{11}, \ldots, d_{1n})$. An up-down vote is taken on the proposal. If a majority votes in favor of d_1, it is implemented, the bargaining game ends, and payoffs accrue (players are assumed to have linear von Neumann–Morgenstern utility functions over their share of the dollar). On the other hand, if the proposal does not win a majority of votes, the process repeats itself: one of the members is selected at random (possibly the same one) to propose a division $d_2 = (d_{21}, \ldots, d_{2n})$. Another up-down vote is taken, and if a majority votes for d_2, the game ends and payoffs accrue, with utilities for member i being discounted by a factor $\delta_i \in [0, 1]$. This process repeats itself until some proposal eventually wins a majority. Payoffs are 0 if no proposal ever wins. One can obtain many variations of this basic game by changing the recognition rule (time dependence, unequal recognition probabilities), the time preferences of the players, the voting rule (weighted voting, super-majority rule, veto players, etc.), allowing for amendments before the vote, having a terminal period T, specifying a status quo in the event no proposal wins, concave utilities, more general feasible sets, and so forth.

While BF games have many similarities to discounted Rubinstein bargaining, they are different in several important ways. First, there are typically an infinite number of subgame perfect equilibria. These arise for the following reason. Equilibrium proposals will offer positive shares of the pie to just enough members to obtain a bare winning majority because buying off additional members is costly but does not change the probability the proposal wins. Therefore, the choice of which members the proposer excludes can, in equilibrium, favor some members over others. In turn, this favoritism (or retaliation) can depend on the history of prior proposals and votes. This allows a huge degree of freedom in the construction of equilibria that was not available in the simple two-person alternating-offer game. This suggests that laboratory testing of the theory may be especially important in establishing an empirical basis for ruling out at least some of these alternative equilibria. Theoretical selections have been proposed. Baron and Kalai (1993), in particular, prove that the simplest equilibrium corresponds to the one that is the natural extension of the unique subgame perfect equilibrium in Rubinstein's game. It is very easy to describe for the standard BF model if recognition probabilities are uniform and all voters are risk neutral and have the same discount factor and the voting rule is majority rule. In that case, the equilibrium reduces to one in which the proposer offers just a large enough share of the pie to a randomly selected coalition of $(n-1)/2$ other members so that each of the members of the coalition is exactly indifferent between voting for or against the proposal. The remaining share of the pie is kept by the proposer. All members out of the coalition vote against the proposal and all members in the coalition vote for the proposal. If a proposal fails, then the next randomly selected proposer makes a similar proposal, and so on. By the symmetry of the game and since there is no delay in this equilibrium, the value of the game to each member of the committee is just $1/n$. Hence, the proposer must offer δ/n to each member of his coalition in equilibrium, and keeps a share equal to $1 - [(n-1)/2](\delta/n)$.[45] A second difference—one that can be convenient for laboratory testing—is that the stationary equilibrium solution is typically well defined even in the limit where the future is not discounted at all ($\delta = 1$). For example, if $n = 3$ and $\delta = 1$ the proposer offers one of the other members a share of $\frac{1}{3}$ and keeps a share equal to $\frac{2}{3}$.

BF Experiments There have been several laboratory studies of the Baron-Ferejohn bargaining model and variations of it. In all versions of these studies, the equilibrium of the standard BF game has had four main properties. First, there is a *proposer advantage*, in the sense that a player is better off being the proposer than not being the proposer. Second, there is *no delay* in the equilibrium, so proposals should always pass. Third, there is *full rent extraction*, in the sense that the members of the proposer's coalition are exactly indifferent between voting for or voting against the equilibrium proposal. Fourth, only *minimum winning coalitions* arise. That is, the proposer offers shares only to enough other members to get a bare majority (or, in the case of a super majority, only the minimum number of votes to pass).

These four properties are also properties of most of the alternating-offer bargaining games that have been studied in the laboratory, and the first and third properties are also properties of the Romer-Rosenthal setter model that was studied in the Eavey-Miller experiment. Thus it should come as no surprise that many of the findings of those experiments find parallels to results from BF experiments. Three parallels are particularly important. First, there is a proposer advantage, but it is less than what the theory predicts. Second, there is sometimes delay. Third, there is not full rent extraction. Clearly, *models that predict full rent extraction by proposers fare poorly if responders are allowed to veto the outcome, either individually or as part of a blocking coalition.* Just like in the ultimatum game or more complicated alternating-offer games, this means the proposer in all these settings must trade off the value of a better proposal against the risk of having it voted down. There is indeed strategic risk in these environments. Whether it is due to social preferences or some other source is still an open question and has been an area of intense study in behavioral economics. For whatever reason, such risk exists, and it implies unpredictability about what responders will or will not vote for. Given that different proposers will tolerate different amounts of risk and presumably have different priors about the responders' range of acceptable offers, this will necessarily lead to some delay. However, while this implies failure of the second and third theoretical properties of equilibrium, the first observation should still be true: a proposer advantage should still be observed. And indeed that is the case, although it is diminished somewhat because of the blocking threat.

The First Laboratory Study of BF The pioneering laboratory study of BF models was McKelvey (1991), which provides a simple test of whether the stationary equilibrium is a good predictor of behavior and outcomes. That paper does not investigate a divide-the-dollar environment but instead investigates what is essentially the simplest possible BF environment: three alternatives $\{A, B, C\}$ and three voters $\{1, 2, 3\}$.

Voter preferences over the three alternatives lead to a Condorcet cycle. The von Neumann–Morgenstern utilties for voter 1 are $(1, 0, v_3)$ for alternatives A, B, and C, respectively; the corresponding payoffs for voters 2 and 3 are $(v_1, 1, 0)$ and $(0, v_2, 1)$, where $v_i \in (0, 1)$ for $i = 1, 2, 3$. The unique stationary subgame perfect equilibrium has proposers always proposing their most preferred outcome (1 proposes A, 2 proposes B, and 3 proposes C). However, in contrast to the "no delay" property in subsequent BF experiments, there is mixing at the voting stage and thus there can be delay in equilibrium. The stationary equilibrium makes sharp predictions about the distribution of proposals, final outcomes, expected delay, and so forth, which are tested using data from his experiment. The design of the experiment varies (v_1, v_2, v_3) and also looks at a four-alternative game where three of the alternatives cycle, exactly as in the first part of the design, and the fourth alternative is "fair" in the sense that it gives everyone the same payoff. In all treatments the discount factor is 0.95 and subjects are paid in lottery tickets to induce risk neutrality.

There are four main findings. The sharpest of these findings is in the four-alternative committees, where unfair outcomes are predicted to arise 100% of the time. Indeed, unfair outcomes are observed over 95% of the time, lending strong support for the stationary equilibrium.

In contrast, with the three-alternative committees, there are three features of the data that clearly contradict the predictions of the stationary equilibrium. First, committee members almost never propose the alternative corresponding to $\min\{v_1, v_2, v_3\}$ if that minimum is very low (which it is for most of the three-alternative committees). In other words, one of the subjects consistently proposes his or her *second-ranked* alternative, thereby avoiding the lowball "offer" to a coalition partner that would result from proposing his or her top-ranked alternative.[46] Because such a proposer's second-ranked alternative corresponds to one of the other members' top-ranked alternatives, this virtually guarantees the proposal will pass, so this is the "safe" strategy for such a proposer. Second, proposals are accepted with higher probability than theory predicts (partly because safe strategies are used). Third, there is significantly less delay than predicted by the theory. McKelvey suggests that these three departures from the stationary equilibrium could be due to risk aversion—that is, a failure of the lottery procedure to induce risk neutral preferences, a failure that has been documented elsewhere.[47] The findings are also consistent with subjects maximizing an objective function that includes a preference for bilateral fairness (outcomes that are fair to one's coalition partner) or a preference for efficient outcomes (i.e., outcomes that maximize the total payoff to the group).

Divide-the-Dollar BF Experiments In the remaining versions of BF games that have been conducted in the laboratory, the theoretical equilibrium has the four properties of proposer advantage, no delay, full rent extraction, and minimum winning coalitions. The first[48] of these experiments (Fréchette, Kagel, and Lehrer 2003) compares open versus closed rules in the proposal/amendment process. The closed rule was described earlier as the standard BF model. The open rule differs by giving a second randomly selected proposer the option of either seconding the proposal (i.e., forcing a vote on the first proposal) or offering a substitute proposal. In case of a substitution, there is a vote between the original proposal and the substitute. The winner becomes the standing proposal, the discount factor is applied to payoffs, and another randomly selected proposal is chosen to either move the question or offer a substitute. The procedure continues until there are no further substitutions and a proposal is passed. There are two differences in the equilibrium of the two games. First, the open rule dilutes proposer power. For, example, in their five-member closed-rule committees with $\delta = 0.8$, the proposer's equilibrium share is 0.68, and his two coalition partners each receive 0.16; but with open rule the shares are 0.52 and 0.24, respectively. The second difference is that the open-rule equilibrium can lead to delay. This occurs if a noncoalition partner (i.e., someone whose proposed allocation equals zero) is selected as the second proposer, which happens with probability $\frac{1}{2}$. In that case, a substitute amendment will be offered, forcing delay.

A number of findings are reported. As in the earlier McKelvey study, they observe—in both open- and closed-rule committees—a proposer advantage, but less than would be predicted by theory; that is, full rent extraction does not occur. Second, the proposer advantage is greater under a closed rule, and this gap widens with experience. Third, the closed rule produces no delay, and the open rule produces considerable delay. Regarding the latter, they find less delay than predicted (as in the McKelvey study). Fourth, proposals converge with experience to ones with minimum winning coalitions.[49]

Fréchette (2009) looks more deeply into the dynamics of behavior across the fifteen rounds. He observes that *initially* proposers demanded approximately the same shares in both the open and closed rules, and it is only after time that the gap appears, as closed-rule proposers increased their demands and open-rule proposers decreased their demands. Second, while minimum winning coalitions are predominant by the later rounds, they are less common in the early rounds. He shows that a belief-based learning model based on Cheung and Friedman (1997) can account for these trends.

Fréchette, Kagel, and Morelli (2005a, 2005b) report results from an experiment designed to test the separate effects of bargaining power and recognition power in a legislature with different-sized parties who have strong party discipline (i.e., always vote as a block). Bargaining power is measured directly in terms of the size of the voting block. Recognition power is measured by the probability of being the proposer in any stage of the BF game. The analysis focuses on three parameter configurations. The first (baseline) is the standard BF model with three member committees. In this case all voters have equal voting weights and equal recognition probabilities. The second treatment has two large parties, each with a voting block weight of $\frac{5}{11}$, and one small party with a voting block weight of $\frac{1}{11}$, and all parties have recognition probabilities equal to $\frac{1}{3}$. The equilibrium strategies are identical to the first treatment: all proposers receive a share of 0.67, regardless of whether they are one of the large parties or the small party, and they choose their coalition partner randomly. The third treatment is the same as the second treatment, except the recognition probabilities are proportional to the voting-block size. Again, the equilibrium solution is the same. While these three treatments produce no effects under the BF model, they do produce large effects under a competing model of coalition formation that has had a significant impact in political science: Gamson's law. Gamson's law predicts that political spoils will be divided in a coalition in proportion to the voting blocks of its constituent members and that the proposer will always choose the "cheapest" coalition partners (the latter also being true for BF). Thus, in treatments 2 and 3 with unequal voting weights, Gamson's law predicts that only coalitions consisting of one large and one small party will ever form, and the spoils will always be divided such that $\frac{5}{6}$ goes to the large party coalition member—regardless of who the proposer is.[50] While the results do not conform exactly to the BF equilibrium predictions (for largely the same reasons as in Fréchette, Kagel, and Lehrer 2003), the findings are nowhere close to the predictions of Gamson's law, except for the baseline treatment. However, there is significant proposer power with experienced subjects even in the baseline session, contradicting Gamson's law.

One final treatment was conducted with equal voting weights but a discount factor $\delta = 0.5$. This change in the discount factor predicts no change in outcomes under Gamson's law but predicts greater proposer power under the BF hypothesis. They find that with the lower discount factor, coalition partners are willing to accept less-generous proposals resulting in an increase in proposer power, at least for experienced subjects. However, the effect is considerably smaller than the predicted equilibrium change.

The class of bargaining protocols laid out in BF is obviously only one of many possibilities. In "real" political bargaining, the structure is not always that clear, and we know from theoretical work on noncooperative bargaining in economics that the exact details of the bargaining protocol can greatly affect outcomes. To the extent that we hope these models (and experiments) can tell us something useful about legislative politics, there is an argument for (1) considering other plausible models of the political bargaining process and (2) trying to compare findings from experiments to field observations of political bargaining outcomes in governments. Morelli (1999) proposes an alternative bargaining format, demand bargaining (DB), whereby voters are randomly ordered, and then make sequential demands following that order until there is a collection of feasible demands (i.e., sum to less than or equal to 1) from a coalition that holds a majority share of the votes. If, after everyone has made their respective demands, there is no feasible winning coalition, then the process starts all over again with discounted payoffs. The equilibrium allocations are indeed affected by the bargaining rules, with BF alternating offer rules generating greater proposer power, and the demand bargaining rules producing equilibrium allocations that are proportional to voting weights, with no first-mover advantage. Fréchette, Kagel, and Morelli (2005c) design an experiment to compare outcomes under the two protocols.[51] They run sessions with five-member committees and no discounting and with two different sets of parameters, one where all voters have equal weights and another where there is one powerful "apex" voter (with three times the voting weight of the smaller, "base" voters). Several sessions used experienced subjects and all sessions consisted of ten elections, using a random matching protocol. Subject payments were based on one randomly selected election.

One difference they observe that is not predicted by the theory is a significant difference in the frequency of delay between BF and DB. There is almost never delay with DB (less than 5% of the elections), but delay is frequent with BF (about 40%), with essentially no experience effects.[52] Some of the BF elections with experienced subjects required as many as seven rounds to reach agreement.[53] Minimum winning coalitions are generally observed in both treatments, with increasing frequency with experience.

Concerning allocations, consistent with past findings, most proposers in the BF committees have some proposal power (receive higher shares than their voting share in a coalition), with the exception being the apex proposers, who receive less than their voting share as proposer. Also consistent with past findings, all the BF proposers have less proposal power than predicted by the stationary subgame perfect equilibrium; correspondingly, coalition partners in the BF committees receive more than their equilibrium allocations.

In contrast, proposers in the DB committees earn *more* than their equilibrium shares (significantly more when experienced). That is, the first movers have proposer power, while the theory predicts they should receive allocations equal to their voting weights.[54] This leads to a central conclusion of the experiment: *There is significantly less difference in outcomes between the two bargaining protocols than is predicted by theory.* The authors then consider the implication of this main finding for the interpretation of regression results from field data. Conducting regressions with their laboratory data, similar to those used with field data to compare DB and BF protocols (Ansolobehere et al. 2005; Warwick and Druckman 2001), they find that such regressions fail to distinguish between the models. On one hand, this casts doubt on the empirical exercise of trying to find out which model corresponds most closely to political bargaining phenomena; on the other hand, the overall finding suggests that perhaps some better intermediate model is lurking in the shadows waiting to be discovered.

Finite Horizon Experiments Diermeier and Morton (2005)[55] and Diermeier and Gailmard (2006) also report a lack of proposer power in their studies of legislative bargaining with asymmetric voting weights and recognition probabilities. Both studies employ a much different experimental protocol. The former looks at finite-horizon bargaining games (maximum of five-rounds); the latter allows only one round and varies the continuation payoffs to committee members in the event the proposal fails. Because they are only one round, the Diermeier and Gailmard study is more closely related to the ultimatum game literature.[56] The former paper examines how proposal and voting behavior changes when the outside option (status quo) payoff to the proposer is varied and find strong effects that don't seem to be consistent with social preference models. The latter paper changes all three status quo payoffs simultaneously and investigates how behavior changes as the sum of the payoffs in the status quo changes. They find that the standard equilibrium model works better when the status quo payoffs are relatively high.

Legislative Bargaining with Public Goods Fréchette, Kagel, and Morelli (2012) investigate the effect of adding a public good dimension to the static BF divide-the-dollar game, following very closely the model of Volden and Wiseman (2007, 2008). In their experiment, a five-member legislature is faced with an exogenous budget which is to be allocated between investment in the public good and private good transfers to the members of the legislature. Production technology is linear: each unit invested in the public good yields 0.7 units of the public good. Preferences are linear in the public and private goods and identical across agents. The marginal rate of substitution between private and public good is $\alpha/(1-\alpha)$, so higher values of α indicate a lower preference for public good production. The BF bargaining model using a closed rule, majority voting, and the uniformly random recognition rule is followed, and the discount factor is $\delta = 0.8$. Because of the linearity of the environment, the predictions of the model are straightforward. For low values of α, the equilibrium proposal is to invest everything, with no private transfers. For sufficiently high values of α, the equilibrium proposal is to invest nothing, with minimum winning coalition transfers equal to the standard BF solution in the divide-the-dollar game. For intermediate values of α, the equilibrium allocation involves both positive amount of public good and positive transfers to a minimum winning coalition. In this intermediate range, the investment in public good increases in α, which is somewhat counterintuitive. For similar reasons, the equilibrium private good allocation to the proposer is nonmonotonic. Figure 6.5 illustrates the nonmonotonic relationship between α and the equilibrium investment in public good.

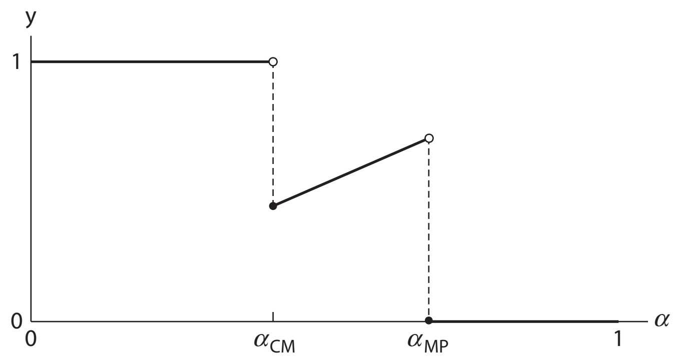

Figure 6.5: Equilibrium public good investment as a function of α.

Their design was organized in a way to provide a simple test of this nonmonotonic relationship between α and both the level of public good investment and the private good allocation to the proposer. The main finding is that the nonmonotonic relationship is not observed. Contrary to the equilibrium, the observed public good levels are monotone decreasing in α, and the proposer shares are monotone decreasing in α. The proposer shares are also much less than predicted by theory, and the public good levels are generally higher than the equilibrium prediction. In fact, the lowest three treatments are nearly indistinguishable from each other with nearly all the allocation in the public good and proposer private allocations less than 10%. The authors find some evidence of learning in the direction of the theory for the $\alpha = 0.55$ and $\alpha = 0.65$ but no such evidence in the $\alpha = 0.45$ treatment.[57] It is likely that there is no learning in the $\alpha = 0.45$ treatment because full investment in the public good is almost an equilibrium. The proposer has little to lose by proposing full investment; in fact, investing everything is the stationary equilibrium for $\alpha \leq 0.42$. This suggests that a quantal response equilibrium analysis of the model might account for this departure from the theory.[58] Another possible factor, perhaps related, is that the equilibrium is "weak" in the middle region in the sense that voters are indifferent between voting for and against the equilibrium proposal. We know from ultimatum games and previous BF experiments that such indifference is a problem in the theory: an offer must leave something on the table or there is a high probability it will be rejected, which is also consistent with quantal response models. In the middle region, as long as α is relatively small, say, 0.45 or 0.55, the obvious (and cheap) way to leave money on the table is to invest more than the equilibrium amount in the public good, which is consistent with the data. In the middle region, if α is relatively large, say, 0.65, the obvious (and cheap) way to leave money on the table is to give away a larger share of the private good, which is also consistent with the data.

Other findings from the experiment mirror results from divide-the-dollar BF experiments. Delay is infrequent; proposers have some power but less than equilibrium; and minimal winning coalitions are commonly observed. The concept of minimum winning coalition here is a bit different from divide-the-dollar games. For low values of α there are no private allocations. In the middle range of α where the equilibrium public good allocation is strictly between 0 and 1, only the proposer should receive a positive private allocation. For high values of α the minimum winning coalition is the usual simple majority.[59]

Principal Findings from BF Experiments

1. There is significant proposer power, which is diminished by having more competitive agenda protocols, such as allowing amendments or following a demand bargaining game form.
2. While proposal power is significant, it is less than predicted by theory. As in ultimatum games, proposers leave some money on the table in order for their proposals to be accepted.
3. There is some delay, but this becomes infrequent with experience, suggesting convergence to the no delay solution. The amount of delay is affected by the agenda protocol.
4. Minimum winning coalitions are most frequently observed, and increasing with experience.

Legislative Bargaining in Dynamic Environments All the legislative bargaining experiments described previously involve purely static allocation problems. While the bargaining protocols are multistage games, there is a simple once-and-for-all allocation that is decided by the committee. As noted before, this approach mirrors traditional models of bargaining in economics in static environments, such as the ultimatum game and offer-counteroffer bargaining games. The theoretical literature in political science has recently applied some of the ideas and insights of the static BF model to truly dynamic environments, where the outcome of the bargaining game at one point in time affects the structure of the bargaining problem in later points in time.

Dynamic Divide-the-Dollar Games with Endogenous Status Quos The simplest way to introduce dynamics is the case where the committee bargaining takes place in the shadow of a status quo and the status quo is determined endogenously by outcomes of the bargaining game in earlier periods. Battaglini and Palfrey (2012) report the results of an experiment with exactly this kind of environment, following a game similar to the dynamic divide-the-dollar game first studied by Kalandrakis (2004). In that model, a legislature or committee of n members must decide in each of an infinite number of periods how to divide a fixed pie into n parts, operating under majority rule. If we denote the allocation in period t by x_t and the proposed allocation in period $t+1$ by y_{t+1}, then the outcome in period $t+1$ is given by

$$\begin{aligned} x_{t+1} &= y_{t+1} \quad \text{if at least } \frac{n+1}{2} \text{ members vote for } y_{t+1} \\ &= x_t \qquad \text{if fewer than } \frac{n+1}{2} \text{ members vote for } y_{t+1} \end{aligned}$$

That is, x_t is the status quo in period $t+1$. Thus x_t can affect the payoffs in all future periods for given proposals and voting strategies in future periods. Payoffs are assumed to be given by the infinitely discounted sum of the shares of the pie received by an agent. The recognition rule is assumed to be random with equal probabilities.

A stationary Markov equilibrium for such a game is defined in terms of proposal and voting strategies that depend only on the current status quo and not on payoff irrelevant variables in the history of play (such as exactly how many votes a proposal received). Kalandrakis shows that in this model, there is a Markov equilibrium in undominated strategies with the property that, regardless of the initial status quo, x_0, the trajectory of the outcomes quickly converges to a rotating dictatorship: whoever is the current proposer in period t proposes to have a share of 1 and to everyone else, 0, and the proposal always passes.

Battaglini and Palfrey (2012) study several variations of this game in the laboratory, inducing the discounted infinite horizon with a constant random stopping rule, δ. In the equilibrium they analyze, voters mix 50–50 if they are indifferent between the proposal and the status quo, and proposers who are indifferent between offering two proposals propose them with equal probabilities. The first two variations limit the set of possible allocations to only four, which simplifies the theoretical analysis and also simplifies the decision problem for the subjects. The four possible allocations in variation 1 are

$$a = \left(\tfrac{1}{3}, \tfrac{1}{3}, \tfrac{1}{3}\right)$$
$$b = \left(\tfrac{1}{2}, \tfrac{1}{4}, \tfrac{1}{4}\right)$$
$$c = \left(\tfrac{1}{4}, \tfrac{1}{2}, \tfrac{1}{4}\right)$$
$$d = \left(\tfrac{1}{4}, \tfrac{1}{4}, \tfrac{1}{2}\right)$$

Thus, variation 1 has one egalitarian allocation, a, and three unequal allocations, b, c, d, in which one of the members receives half the pie and the other two split the remaining half. In this variation the egalitarian allocation is a Condorcet winner, and there is a unique equilibrium, the trajectory of which depends on the initial status quo. If the initial status quo is equal to a, then in this equilibrium a will always win in every future period. In other words, a is an absorbing state. However, if the initial status quo is b, c, or d, then the trajectory is similar to the equilibrium identified by Kalandrakis—it randomly rotates between the three unequal allocations forever, *never reaching the absorbing state of* a.

In variation 2, the four feasible allocations are

$$a = \left(\tfrac{1}{3}, \tfrac{1}{3}, \tfrac{1}{3}\right)$$
$$b = \left(\tfrac{1}{2}, \tfrac{1}{2}, 0\right)$$
$$c = \left(0, \tfrac{1}{2}, \tfrac{1}{2}\right)$$
$$d = \left(\tfrac{1}{2}, 0, \tfrac{1}{2}\right)$$

The only change here is that the unequal allocations are now split between two members of a minimal winning coalition. This seemingly minor change in payoffs has a huge effect on the equilibrium. In this case, there is no longer a Condorcet winner. Indeed, now a is a Condorcet loser. As a result, it can be shown that the equilibrium involves randomly alternating between allocations b, c, d.

Two sessions were conducted for each of variations 1 and 2. In each session subjects played one of the variations ten times with random rematching and a discount factor of $\delta = 0.75$. The variation 2 findings were largely consistent with the theory. Looking at the empirical transition frequencies, if the current status quo was a *majoritarian* allocation (b, c,or d), then the outcome in that round was nearly always (98% of the time) *majoritarian*. In contrast, the egalitarian status quo was unstable, with outcomes moving from a to a minimum winning coalition half the time. In fact, 70% of the proposals were for minimum winning coalitions when the status quo was a.

The results for variation 1, where a is a Condorcet winner, were somewhat further from the equilibrium. On one hand, a was a very stable outcome, as predicted. When a was the status quo in period t, the outcome was nearly always a (94% of the time). However, the nonegalitarian outcomes were less stable. When the status quo was b, c, or d, the outcome was an unequal allocation 62% of the time. Thus, what is observed in the long run when there was a Condorcet winner is that if the status quo is an unequal allocation, then with fairly high probability it will bounce to a, in contrast to the theoretical prediction that there are two absorbing sets of allocations, $\{a\}$ and $\{b, c, d\}$.

Nearly any model introduces some error, or "noise," into the proposal, and voting strategies in the game would predict transitions of this kind. With this in mind, the authors define a generalization of quantal response equilibrium that applies to Markov equilibria in infinite horizon games such as the ones studied in the paper. This equilibrium, called *Markov Logit equilibrium* (*MLE*) applies the framework of the agent quantal response equilibrium (McKelvey and Palfrey 1998), so it combines sequential (quantal) rationality and stationarity of strategies and the Logit specification of stochastic choice. They solve numerically for the MLE value function, and players Logit-best-respond given the MLE value function. For *any* value of the Logit noise parameter, λ, the model predicts a stochastic long-run alternation between the absorbing regions in variation 1, qualitatively similar to the one observed in the data; and it predicts relative stability of the $\{b, c, d\}$ region in variation 2. They estimate the value of λ that best fits the data and report a close match between MLE and data.

The third variation was much closer to the Kalandrakis model of divide-the-dollar because proposals were not constrained to be one of four proposals but could be essentially any three-way split of the dollar, using a relatively fine discrete grid.[60] The equilibrium of this game is similar, but not identical, to Kalandrakis, partly because of the discrete grid on allocations. Recall that in the Kalandrakis equilibrium, the prediction is to rotate between the vertices of the simplex, corresponding to one member receiving the entire dollar. In the equilibrium for the discretized version of the game, the equilibrium involves rotations between regions close to the vertices, but not exactly at the vertices.

Three sessions were conducted for this divisible variation, two with $\delta = 0.75$ and one with $\delta = 0.83$. In both cases, there was a lot of clustering and stability to allocations far away from the vertices, in contrast to the theory. In fact, outcomes close to the vertices were quite rare (less than 20% of the time). Outcomes were either perfectly or nearly egalitarian more often than that, and over 60% of the allocations were approximately minimum winning coalition allocations, where two of the members received large allocations and the third member received a zero or token allocation. Using numerical computations to characterize neutral solutions when utilities are concave rather than linear, the authors are able to show that as concavity increases the long run distribution of allocations becomes more equitable. Figure 6.6 shows the expected long run distribution of allocations when voters have CRRA utility functions with parameter γ, where linear utility corresponds to $\gamma = 0$.

In this sense the data suggest that perhaps the linear utility assumption is too strong. Using MLE as an error structure the authors estimate the degree of concavity, assuming constant relative risk aversion. Their risk-aversion estimate (approximately a square root utility function) is close to what has been found across a broad range of other experimental studies. Concavity is also consistent with the finding in variation 1, that the egalitarian regime is much more stable than the regime corresponding to rotation

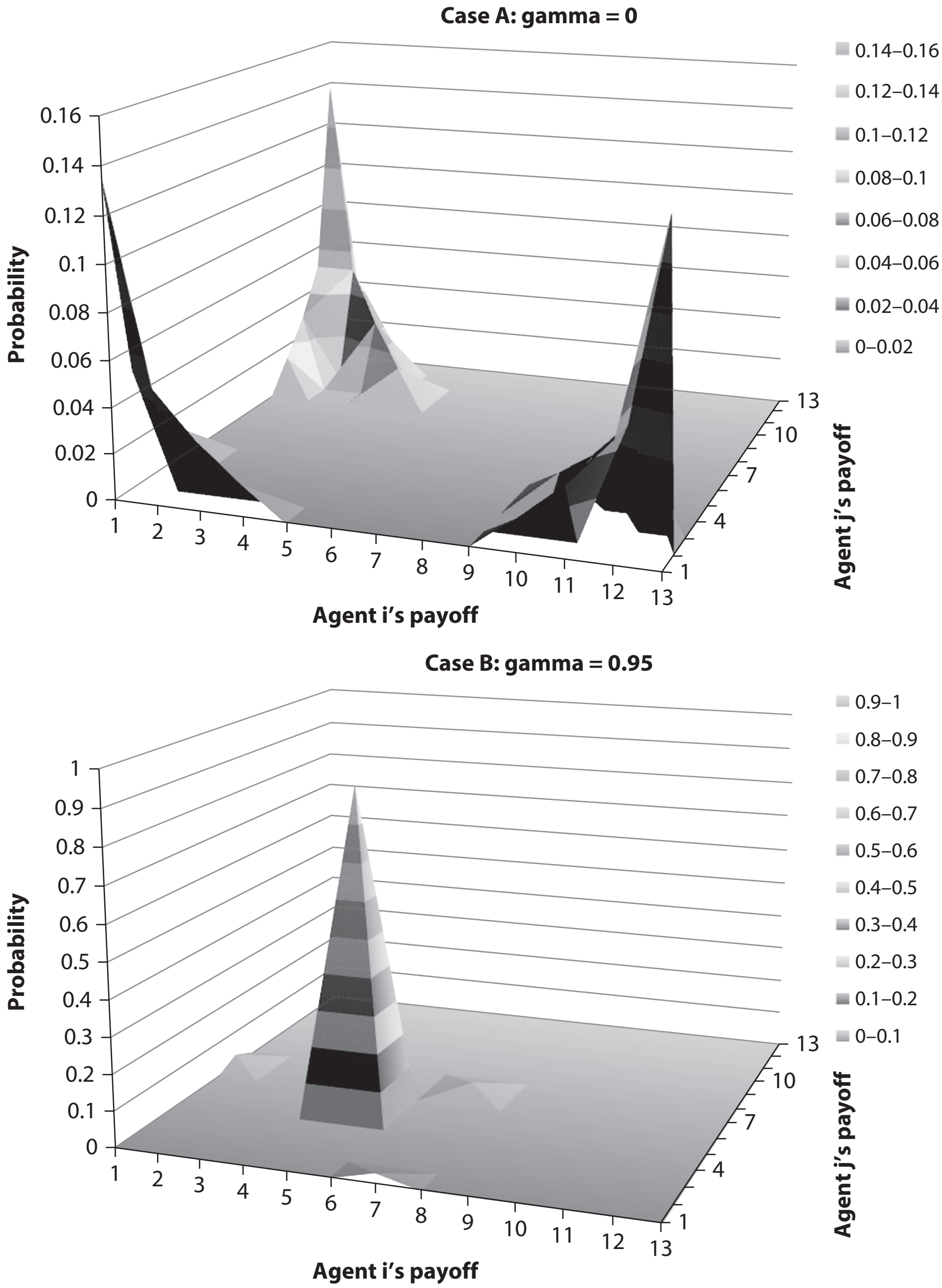

Figure 6.6: Long-run distribution of allocation for low (*top panel*) and high (*bottom panel*) levels.

between unequal allocations. One final note about the behavior in these experiments is that behavior is largely consistent with a model of perfectly selfish players, with little indication of other-regarding preferences. Voting behavior, in particular, can be explained quite well by a model of pure self interest.

Principal Findings for Dynamic Divide-the-dollar Games

1. Allocations over time are "smoother" than predicted by the theory. This is consistent with voters having concave utility functions.
2. Minimum winning coalitions are observed about as much as in BF bargaining games.
3. Proposals are usually accepted. Egalitarian proposals are fairly common and are virtually always accepted.

Dynamic Legislative Bargaining with Durable Public Goods Battaglini, Nunnari, and Palfrey (2012) propose a framework for studying the political economy of durable public good production along the lines of models of economic growth. They establish some basic theoretical results about the effect of the voting rule on the investment path of the public good when the path is chosen over a sequence of periods with a legislative bargaining game. Specifically, the environment consists of many citizens divided into n equally sized districts, each with a single representative in the legislature. All citizens have the same per-period utility function, which is linear in the private good with an additively separable concave utility, $u(y_t)$, for the current stock, y_t of the durable public good. There is an infinite horizon and a discount factor δ. In each period, there is an endowment equal to W and a *policy* in period t is an $n+1$ vector, where the first component equals the investment in the durable public good, I_t, and the last n components, $x_t = (x_{1t}, \ldots, x_{nt})$, are the private good transfers to each district. The investment increases the stock of the durable public good, and the durable public good depreciates at rate d in each period. Hence, the stock of public good in period t is equal to $y_t = (1-d)y_{t-1} + I_t$, and an allocation sequence is $\{x_t, y_t\}_{t=1}^{\infty}$. Feasibility requires $x_t \geq 0$, $y_t \geq 0$, and $y_t + \sum_{i=1}^{n} x_{it} = W$, for all t. Voter i values an allocation sequence as the discounted sum of per-period utility of the sequence, that is, $\sum_{t=1}^{\infty} \delta^{t-1} [x_{it} + u(y_t)]$.

The bargaining game is simple. In each period one of the n legislators is randomly selected to make a proposed allocation (y_t, x_t), and an up-down vote is conducted in the legislature under a closed rule. Voting follows a q-$rule$, where the proposal passes if and only if it receives at least q votes in favor. If it fails, then a status quo outcome occurs. They consider a simple exogenous status quo outcome, (y_0, x_0), where $y_0 = 0$ and $x_{it} = W/n$ for all i.

There are several theoretical properties of the model that can be examined by a laboratory experiment. First, for all values of q and other parameters in the model, the symmetric continuous Markov perfect equilibrium investment paths are inefficient. Second, this inefficiency decreases with q.[61] In the case of unanimity rule, the steady-state level of the stock of public good is actually equal to the optimal level, although the speed of approach to the steady state is too slow, as proposers skim off some resources for private consumption in each period.

The article reports results from an experiment with legislatures of size $n = 5$ and three different voting rules: simple majority rule ($q = 3$), unanimity rule ($q = 5$), and dictatorship ($q = 1$). In all the treatments, there is zero depreciation ($d = 0$), square root utility functions, and a discount factor of 0.75 is implemented using a random stopping rule with constant probability of $\frac{1}{4}$. Figure 6.7 shows the median time paths of y_t for the first ten periods for each of the three q rules. The theoretical equilibrium levels of y_t are marked in the figure.

There are several main findings. First, consistent with the Markov perfect equilibrium, the level of investment is far below the efficient level and converges over time

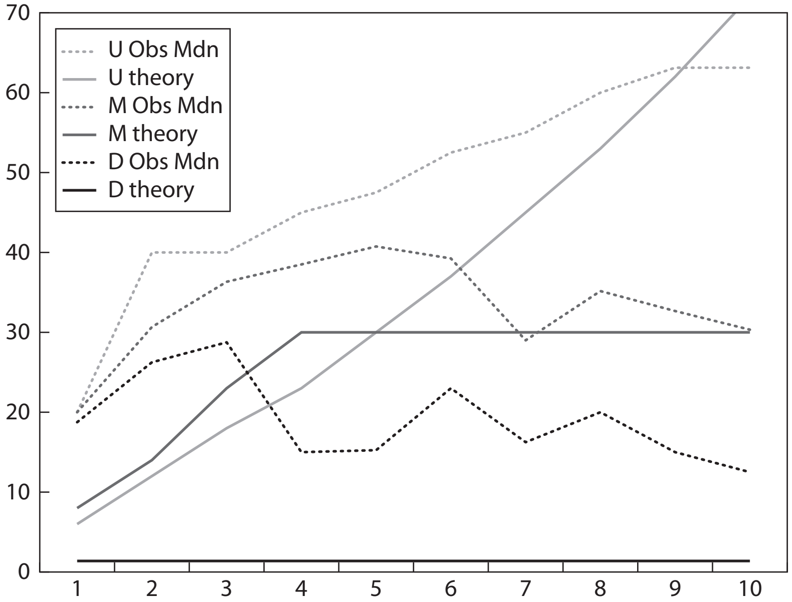

Figure 6.7: Theoretical and median time paths of y_t for different voting rules. *Source*: Battaglini et al. (2012).

to levels much closer to the steady state of the Markov perfect equilibrium.[62] Second, the unanimity voting rule produces the most efficient outcomes, dictatorship, the least efficient, and majority rule, in between, as predicted. Investment with $q = 3$ (majority) levels off at nearly triple the size compared to $q = 1$ (dictatorship). Investment with $q = 5$ (unanimity) converges to approximately six times the size compared to $q = 1$. Third, the path of convergence to a steady state is different from the theory. There is overshooting—that is, the legislatures overinvest in early rounds and then disinvest in later rounds. In all three q treatments, the trajectory has the same pattern of early overinvestment followed by later disinvestment. Fourth, most proposals pass, as is consistent with the findings in the static games discussed earlier. Fifth, approximately minimum winning coalitions are the norm. While the proposals observed often have positive transfers to all districts, most of the transfers are concentrated in a minimum winning coalition.

Battaglini, Nunnari, and Palfrey (2014, 2015) consider a variation of the model in which the investment in the stock of public good in each period is made in a completely decentralized way, with each district deciding independently how much of their (equal) share of the endowment (W/n) to invest in the public good. This produces an economic environment that is a dynamic voluntary contribution game, where the public good is durable, rather than the standard static model, where the public good is nondurable. The voluntary-contributions mechanism is similar to many of the more traditional static public goods games, as surveyed in Ledyard (1995). The main difference is that with a durable public good, the public good level increases over time, and current contributions add to the stock of the public good, which produces a stream of public benefits over time. In the traditional static public goods experiments, public good contributions produce benefits only in the current period. Often those traditional public goods experiments are

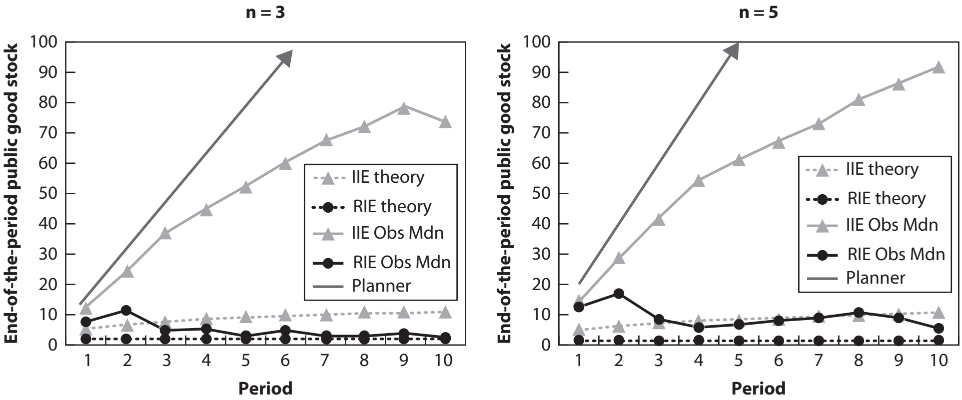

Figure 6.8: Theoretical and median time paths of y_t in dynamic free riding. Battaglini et al. (2015).

repeated several times in order to study learning dynamics, but there is no accumulation of stock; the level of public good is zeroed out at the start of each period.

The durable public goods experiment with decentralized public good investments is reported in Battaglini, Nunnari, and Palfrey (2015), and the design is organized in a way to examine the theoretical results reported in Battaglini, Nunnari, and Palfrey (2014). The latter paper characterizes the symmetric continuous Markov perfect equilibria of the game and obtains comparative static results with respect to the discount factor, the rate of depreciation, the group size, and the concavity of the utility function. It also considers two different technologies of public good production, depending on whether investments in the public good are reversible. In particular, they show that the reversible case leads to lower public good contribution than the irreversible case. This comparison is especially stark in the case of no depreciation, so the experiments focus on that case.

The experiment reported in Battaglini, Nunnari, and Palfrey (2015) varies the group size between three and five and includes both reversible and irreversible investment treatments. The discount factor of $\delta = 0.75$ is used in all treatments. The basic procedures are similar to the legislative bargaining, with the only difference being the voluntary contribution mechanism instead of the legislative bargaining mechanism. The two main findings are that (1) there are significantly more contributions with irreversible investments than in the reversible case, and (2) there are also more contributions with $n = 5$ than with $n = 3$, but the difference is small and not significant. Figure 6.8 shows the median time paths of y_t for the first ten periods. The theoretical equilibrium levels of y_t are marked in the figures. The experiment generally finds support for the predictions of the Markov perfect equilibrium but with similar caveats as described earlier with respect to the experiment of Battaglini, Nunnari, and Palfrey (2012).

Principal Findings for Durable Public Goods Experiments

1. Most proposals are for (approximately) minimum winning coalitions and most proposals pass.
2. The proposer has significant proposer power.
3. Efficiency is increasing in the q rule, as predicted by the Markov perfect equilibrium, and is much less than the optimal solution.
4. The public good level converges to approximately the long-run steady state of the Markov perfect equilibrium.

5. The dynamics of convergence is characterized by overshooting the steady state in early periods and then either leveling out (if investments are irreversible) or drifting back down through disinvestment toward the equilibrium steady state.
6. Voting behavior is generally consistent with long-run optimal behavior, in the sense of the Markov perfect equilibrium value function.
7. Contributions are higher when investments in the public good are irreversible.

3 ELECTIONS AND CANDIDATE COMPETITION

While the first wave of experiments in positive political economy centered around cooperative game theory and unstructured bargaining in committees under majority rule, a second wave of political science experiments followed quickly on the heels of the first, and investigated the question of Condorcet winners and the majority rule core in the context of competitive elections rather than small committees. These studies address many of the same questions that have received the attention of empirical political scientists. The key questions we will focus on here are: (1) spatial convergence of candidate platforms in competitive elections; (2) retrospective voting; and (3) the importance of polls in transmitting information to voters and coordinating voting behavior in multi-candidate elections.

3.1 The Spatial Model of Competitive Elections and the Median Voter Theorem

3.1.1 Two-candidate Elections with a Majority-rule Core

The median voter theorem says that under certain conditions, in two-candidate winner-take-all elections, candidate platforms will converge to the ideal point of the median voter. The theorem applies under fairly general conditions in one-dimensional policy spaces with single-peaked preferences and under more stringent conditions in multidimensional policy spaces. Basically, if Condorcet winners exist, they correspond to the symmetric pure-strategy Nash equilibrium of the game between two office-motivated candidates. Casual observation indicates significant divergence of candidate and party platforms, even in winner-take-all elections. Laboratory experiments can help us understand why this may happen by providing some empirical evidence about the conditions required for convergence.

There has been extensive work on candidate competition where voters have Euclidean preferences and a Condorcet winner exists. The early contributions to this effort are mostly by McKelvey and Ordeshook, and much of this is detailed in their 1990 survey. The focus of this work has been on questions about the informational conditions that are needed for convergence to equilibrium in candidate competition games. The simplest and least challenging environment is one where the candidates have complete information about voter preferences, so the existence and location of the Condorcet winning platform is common knowledge.[63] This is the environment used in their initial study (McKelvey and Ordeshook 1982), which was further simplified by having only candidates as subjects, with the behavior of five voters implemented by automatically voting for the closest candidate. There were ten repetitions of the candidate-competition game. In each play of the game, the candidates simultaneously chose locations in a two-dimensional space and were then told the electoral outcome and the location chosen by the other candidate. A candidate received a positive payoff whenever he or she won an election, with ties broken randomly if both chose the same location.

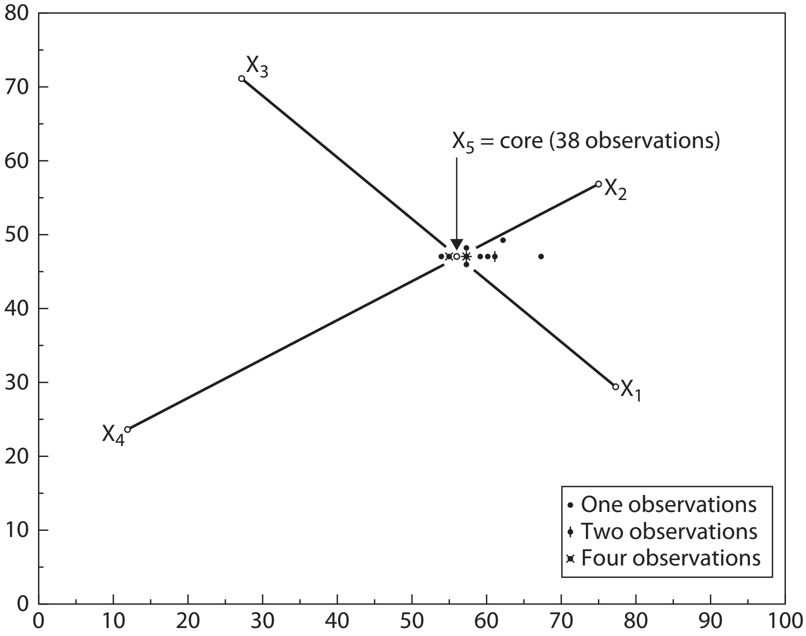

Figure 6.9: Election outcomes in the last five repetitions, where x_i denotes the ideal point of voter i.

Outcomes converged to the Condorcet point.[64] The distribution of outcomes in the last five repetitions is shown in Figure 6.9. More than half of the observations are exactly at the majority-rule core point.

More challenging environments involve relaxing the assumption that candidates have complete information and implementing voting behavior with human subjects rather than by artificial actors.

Principal Finding for Competitive Elections with a Core

- When a majority-rule core point exists, with enough repetition and learning, the outcomes of an election game between two candidates converges to the Condorcet winner. If a majority-rule core point fails to exist, outcomes are concentrated in a central region of the Pareto set, as if generated by the distribution of locations in a mixed-strategy equilibrium.

3.1.2 Information Aggregation by Preelection Polling

The first experiment where polls are used to aggregate information were conducted by Plott in the mid-1970s, with the results later published in Plott (1991). In these experiments, there were between 19 and 41 voters (human subjects) with ideal points in a two-dimensional space, configured so that there was a Condorcet winning point. There were two office-motivated candidates,[65] who were uninformed of the voters' ideal points. All they knew was that the policy space was a specific rectangle in two-dimensional space. In each election, candidate positions were initialized near the edge of the policy space, far from the Condorcet winner. At any time, either candidate could revise his or her platform by announcing a new (tentative) location. Candidates could

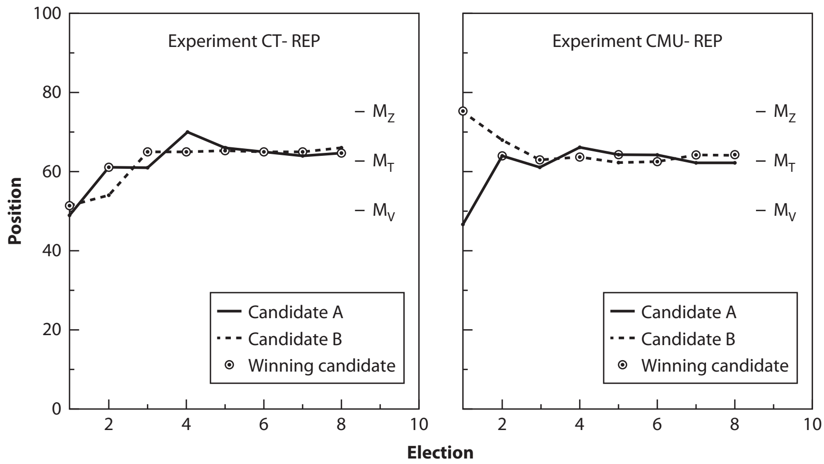

Figure 6.10: Time paths of candidate locations. *Source*: McKelvey and Ordeshook (1985b).

also query voters about how many would prefer them to move in some direction. In addition, public straw votes were conducted periodically by the experimenter, based on the current (tentative) platforms of the two candidates. At the end of a prespecified time period, each candidate announced his or her *final* position, which could not be changed. The election was then held, with the winner receiving \$10 and the loser, \$1. The data include ten such elections with two candidates. In seven of ten elections, the outcome was exactly the Condorcet point. The other three elections resulted in outcomes very close to the Condorcet point.

McKelvey and Ordeshook (1985a, 1985b) push the information question further by studying elections where voters have poor information about the candidate locations. In these studies, they pursue a variety of issues, mostly related to the question of how much information was required of voters and candidates in order for competitive elections to converge to the Condorcet winner. Perhaps the most striking experiment was reported in McKelvey and Ordeshook (1985b) study of candidate competition in a one-dimensional policy space. In this experiment, not only did candidates have no information at all about voters, but only half of the voters in the experiment knew where the candidates were located. The rest of the voters were informed only about the left-right ordering of the candidates. The key information-transmission devices they explored were polls and interest group endorsements. In a theoretical model of information aggregation adapted from the rational expectations theory of markets, they proved that this information alone is sufficient to reveal enough to voters that even the uninformed voters behave optimally, that is, as if they were fully informed.[66] A corollary of this is that the candidates would converge to the location of the median voter. Two sessions were conducted, each with two candidates and between forty and fifty voters. The game was repeated eight times to allow for learning and convergence. The experiment finds strong support for candidate convergence as if information were fully revealed to voters, and even more surprisingly, they converge very close to the median voter. Figure 6.10 shows the time path of locations of the candidates for each of the two sessions, with M_T denoting the ideal point of the median voter, M_I denoting the ideal point of the median *informed* voter, and M_U denoting the ideal point of the median *uninformed* voter.

However, in an extension of this experiment to two dimensions, candidate convergence is much slower; only half the candidates converge to the Condorcet winner with replication.

A number of studies have followed up on this theme of limited-information elections. Dasgupta and Williams (2002) also explore the information transmission properties of polls when some voters are informed and others are not. Their setup differs in a number of ways. First, candidates differ along a quality, or valence, dimension as well as a policy dimension. The policy positions of the candidates are assigned by the computer and are publicly known. One is assigned the leftmost position on a one-dimensional scale, and the other is assigned the rightmost position. Second, the quality type of each candidate is unknown to voters at the time of election, but a subset of voters receive some information about the quality of one of the candidates, who has an opportunity to take a costly action to increase voter beliefs about his or her quality.[67] A sequence of three opinion polls (straw votes) is then conducted, with all voters participating in the poll and with the outcomes publicly observed. Then the actual election occurs and payoffs accrue based on the outcome. In a manner similar to McKelvey and Ordeshook (1985b), they develop a rational expectations equilibrium model adapted to this environment, in which information of the informed voters is transmitted to the other voters as a result of the polls. The findings are broadly supportive of the information-aggregation properties of polls.[68]

Principal Findings for Information Aggregation by Preelection Polling

1. Poll information and interest-group endorsements successfully aggregate information even when most voters have very little information a priori.
2. This kind of public information is sufficient to lead to convergence of candidates to the majority-rule core point with sufficient repetition.
3. The convergence to the core point is much slower in two-dimensional policy spaces.
4. The information aggregation properties of polls extends to aggregating information about candidate quality.

3.1.3 Retrospective Voting

Political scientists have often wondered whether competitive electoral outcomes can arise purely from retrospective voting. The earlier set of experiments with rational expectations and polls was entirely forward-looking and evaluation of candidates was prospective, very much in the Downsian view of electoral competition. But many leading figures in political science have argued that voter evaluations of candidates are backward-looking, and individual voting decisions depend largely on past records of candidates or current economic conditions.[69] Collier et al. (1987) and McKelvey and Ordeshook (1990a)[70] study two-candidate elections where voters observe only the payoff they receive from the winning candidate—not even the policy adopted by the winning candidate or the proposed policy (or payoff) of the losing candidate. There are no campaigns or polls. Voters either reelect the incumbent or vote him or her out of office, in which case the other candidate becomes the new incumbent. “Voters observe historical information about their payoffs (real income) derived from the policies (spatial positions) of previous incumbents, but they do not observe these policies directly. Further, to model the situation in which voters do not even conceptualize

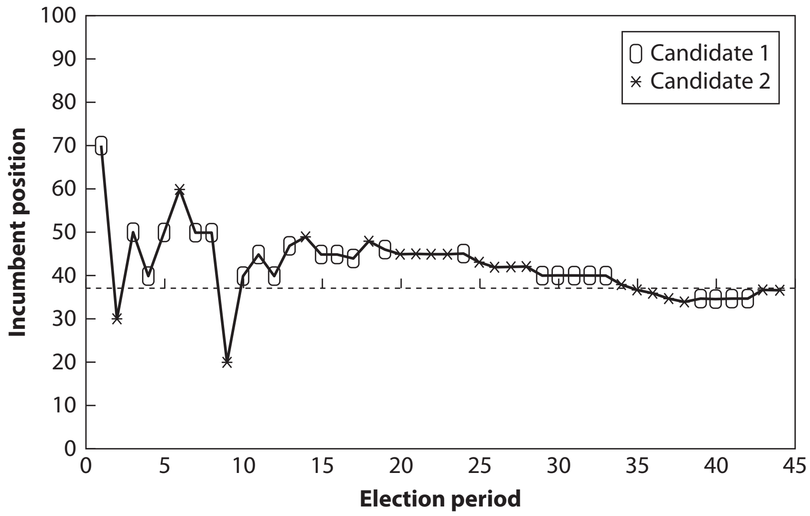

Figure 6.11: Time paths of candidate platforms. *Source*: Collier et al. (1987).

elections in terms of issues, the voters in our experiments are uninformed about the specific relationship (payoff function) between an incumbent's policy and their welfare. Nor do they know that an incumbent's strategy concerns the selection of positions in some policy space" (McKelvey and Ordeshook 1990a, p. 283). Candidates are somewhat better informed in that they know what the policy space is, and they observe all the platforms that their opponent has adopted in the past when in office as well as the past election results. However, candidates are given no information about the distribution of voter ideal points or how each voter has voted in past elections. The main finding is that on average candidates converge to the median, even in this information-poor environment (McKelvey and Ordeshook 1990b).

In the baseline treatment, candidates receive a dollar for each period they are the incumbent. Approximate convergence of candidate platforms is not immediate but generally is achieved by the end of a session, after between 30 and 45 repetitions.

Figure 6.11 illustrates platform convergence for one of the baseline experimental sessions that lasted for 45 periods. The median voter's ideal point is marked by the dashed line, and the points connected by the solid line represent the winning platforms in each period (which voters of course do not see). Platforms converged almost perfectly to the median voter's ideal point in the session after a brief period of volatility at the beginning when candidates were still learning. There were several variations on this baseline design to explore the robustness of convergence. In the first extension, candidates have policy preferences. Rather than earning a fixed amount when elected, the incumbent receives a payoff that is a linearly increasing function of the location they choose in the [0, 100] interval. Convergence is still achieved, although more slowly. In the next variation, the two candidates have opposing policy preferences. One candidate's payoff function is linearly increasing on the [0, 100] interval, while the other's is linearly decreasing. Again, convergence is achieved, but with a clear alternation of policies. The first candidate tends to choose policies above the median and the opposite for the second candidate, with the biases attenuating over time. Finally, they conducted a variation where the location of the median voter was shifted after period 21, without informing the candidates of this shift. Although there is a slight lag, candidates converge surprisingly fast to the new median location.

One of the collective implications of these results about elections with limited information is that it appears to be irrational for voters to gather costly information if other sources of information such as polls, endorsements, incumbent past performance, and word-of-mouth are virtually free. This point is made explicitly in Collier and others (1989), which explores the question with twenty-four laboratory elections, where voters are given an opportunity to purchase information about a challenger's policy if elected, in addition to the free retrospective information that all voters receive about the past performance of the incumbent. That paper and Williams (1991b) explore voter behavior and candidate convergence by giving voters the option to gather costly information about candidates. They find that the amount of information purchased by voters is correlated in the expected (negative) way with the stability of candidate strategies, the imprecision of the information, and the probability of casting a pivotal vote.

While this research does not resolve long-standing questions about the responsiveness of democratic institutions, it does add to what we understand about responsiveness by demonstrating conditions under which incompletely informed voters can generate the electoral outcomes that they would have if better informed. This research also informs the debate about the use of the referendum and initiative to determine policy. One answer to the question, is direct legislation a useful mechanism for obtaining policy outcomes that correspond to the will of the majority or is it a way for small, wealthy interest groups to subvert the popular will? is that direct legislation can be both. When voters are poorly informed (or the electoral alternatives are reasonably complex) and there are no effective information cues available, small groups who have enough resources to obtain agenda control can use direct legislation to obtain preferred outcomes. When meaningful cues are available (or the effect of electoral alternatives are easy to understand), then direct legislation can be a useful tool for the implementation of majority-preferred policies.

These experiments establish two important facts. First, even in laboratory elections where the stakes are low, election outcomes are well approximated by median voter theory. The Condorcet winner (core) is an excellent predictor of competitive election outcomes. Second, this result is robust with respect to the information voters have about candidates and the information candidates have about voters. Precious little information is needed—a result that mirrors laboratory demonstrations that markets converge quickly to competitive equilibrium prices and quantities, even with poor information and few traders. In the discipline of political science, there has been great concern about how uninformed most of the electorate is about candidates and policy issues. One reason for this concern was a widely shared belief that these information failures could doom competitive democratic processes. The McKelvey and Ordeshook series of experiments casts doubt on this doomsday view. Just as financial markets can operate efficiently with relatively few uninformed traders or with many slightly informed traders, the forces of competition can lead to election outcomes that accurately reflect public opinion, even if voters know very little about the candidates, and vice versa.[71]

Principal Findings for Information Aggregation by Retrospective Voting

1. Historical information about past performance of candidates is sufficient to lead to convergence of candidates to the majority-rule core point with sufficient repetition in simple environments.

TABLE 6.1:
Voter preferences.

	Winner			
Preference type	*A*	*B*	*C*	*No. of Voters*
1	\$1.20	\$0.90	\$0.20	4
2	\$0.90	\$1.20	\$0.20	4
3	\$0.40	\$0.40	\$1.40	6

Source: Forsythe et al. (1993, 1996).

2. The findings are *robust* with respect to a variety of modifications of the environment, including unannounced shifts of the median voter location and extreme candidate policy preferences.
3. All the findings of this section are broadly supportive of the hypothesis that competitive elections in sufficiently simple environments can lead to Condorcet outcomes even when voters have very poor information.

3.2 *Multicandidate Elections*

In many elections, more than two candidates are competing for a single position using plurality rule. In these multicandidate elections, there is a natural ambiguity facing voters in the form of a coordination game, and equilibrium places few restrictions on outcomes: that is, there are multiple Nash equilibria. To illustrate this, consider a three-candidate election, with the candidates, A, B, and C having three distinct positions on a one-dimensional issue scale, say, the interval $[-1, 1]$. Suppose there is a large number of voters with ideal points scattered along the interval. Voters know their own ideal point but have only probabilistic information about the other voters. Then, in a winner-take-all election, for any pair of candidates $\{i, j\}$, there is a Bayesian equilibrium in which only these two candidates receive any votes, with each voter voting for whichever of the two is closer to his or her ideal point. This is an equilibrium because it never (instrumentally) pays to vote for a candidate for whom nobody else is voting. Indeed there can be some other equilibria, too (Palfrey 1989; Myerson and Weber 1993), but two-candidate equilibria are the only ones that are stable (Fey 1997). Voters face a coordination problem. Which two candidates are going to be receiving votes? Will a Condorcet winner be chosen if it exists?

Forsythe and others (1993, 1996) explore these and other questions in a series of experiments. Their laboratory elections had three categories of voters defined by different preference orders over the three candidates. One group preferred A to B to C. The second group preferred B to A to C, and the third group ranked C first and was indifferent between A and B. The third group was the largest, but was less than half the population. Groups 1 and 2 were the same size. The actual payoff tables and preference configurations are given in Table 6.1.

Hence, if voters voted for their first choice, C will win, but C is a Condorcet loser, since it is defeated by both A and B in pairwise votes. There are several equilibria, including the two where type 1 and 2 voters coordinate on either A or B. However, because of the special configuration of preferences and because there is complete information, sincere voting is also an equilibrium, resulting in the Condorcet loser, C, winning.

The procedures were carefully designed to avoid repeated-game effects, to minimize possible effects of extraneous coordination devices, and at the same time allow subjects to gain experience at the task.[72] Each experimental session was conducted with twenty-eight subjects divided into fourteen-member voting groups and repeated over a series of twenty-four periods. Thus each session generated data for forty-eight elections, with fourteen voters in each election. Voting groups and preference types were randomly reshuffled after every election.[73]

First, the authors note that without any coordinating device, there is coordination failure. Some voters in groups one and two vote strategically (i.e., for their second choice, trying to avoid C) but many don't, and the strategic behavior is poorly coordinated, so as a result the Condorcet loser wins 90% of the elections.

Second, they look at three kinds of coordinating devices: polls, past elections, and ballot position. Polls allow the voters in groups 1 and 2 to coordinate their votes behind either candidate A or candidate B. This is indeed what usually happens. The Condorcet loser wins only 33% of the elections. Moreover, when either A or B is first ranked in the poll, the Condorcet loser wins only 16% of the time. Election history also helped with coordination. There was a small bandwagon effect between A and B. Whichever was winning in past elections tended to win in future polls. Ballot position had an effect on voting strategies, but the effect was too small to influence election outcomes.

Their second paper looks at alternative voting procedures, comparing plurality rule to the Borda count (BC) and approval voting (AV).[74] Both procedures worked better than plurality rule, in the sense that the Condorcet loser was more easily defeated. Both procedures tended to result in relatively close three-way races, with A or B usually winning. Plurality, in contrast, produced close three-way races but with C usually winning. A later study by Bassi (2015) delves more deeply into a comparison of strategic behavior under these three voting rules. That study differs from the earlier studies in three ways: the preference profile, the number of voters (five instead of fourteen), and the number of alternatives (four instead of three). The two profiles employed in the design have the property that iterated deletion of dominated strategies eliminates all but one equilibrium, so the coordination problem created by multiple equilibria is not present. The main finding is that voting is most sophisticated (i.e., most consistent with equilibrium) under plurality and least sophisticated under BC, with AV in between.

Rietz, Myerson, and Weber (1998) follow up this experiment with a very similar one that explored whether campaign contributions can have a similar coordination effect. In this variation, before each election, each voter independently decided on campaign contributions. Each voter was allowed to contribute (at real expense) up to \$0.20 in penny increments. These contributions could be spread across any subset of candidates or none at all. The total contributions for each candidate were then publicly revealed prior to the election stage. The results were similar to the results from the polling treatment, with the Condorcet loser winning only 33% of the time. The type 1 and 2 voters generally coordinated on whichever candidate, A or B, received the most contributions. Moreover, even accounting for its direct cost, campaign contributions increased coordination enough to lead to higher overall efficiency compared with no contributions.

Another question is whether campaign-contribution decisions were consistent with an equilibrium of the two-stage game. The paper does not offer any model of equilibrium for the more complicated game, where the first stage is contribution and the second stage is voting, but instead argues that the contribution levels do not seem irrational, at

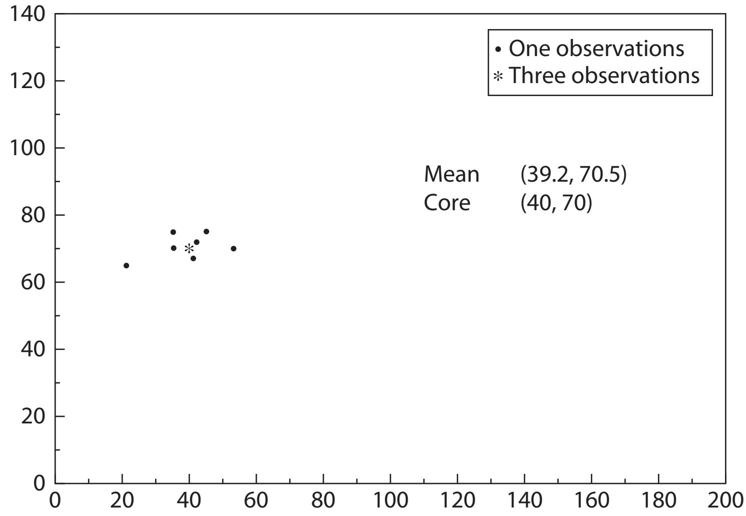

Figure 6.12: Winning platforms in three-candidate elections. *Source*: Plott (1991, 22).

least for the type 1 and 2 voters, in the sense that the marginal benefit from an additional incremental contribution is lower on average than the cost, while the marginal benefit from the last nickel contributed is higher.[75] However, this is done as a back-of-the-envelope calculation rather than a careful statistical analysis, and there is a significant free-rider dimension in the contribution stage.

There are a number of other papers that conduct experiments on related three-candidate coordination games. The earliest work is by Plott (1991),[76] who investigates three-candidate races in a two-dimensional policy space. The setting is different in the sense that candidate locations were endogenous and were sequentially chosen and mixed in with occasional straw votes, with the same procedures as described for the two-candidate elections reported in the same paper. Thus, candidates were adjusting positions over time, and there was a majority-rule core. Unfortunately, there is little guidance in the way of useful predictions based on Nash equilibria. Still, winning-candidate locations tended to converge to the core, but with only slightly more more variance than in the two-candidate baseline treatment. In the ten three-candidate elections, three outcomes were exactly at the Condorcet point and the seven others were close. See Figure 6.12.

Rapoport, Felsenthal, and Moaz (1988a, 1991) examine bloc voting in three-candidate elections, where all voters with identical preferences vote identically. Their design considers a variety of preference profiles in order to compare the predictions of several alternative voting models for selecting among the many Nash equilibria of the game. They propose a model of equilibrium selection based on implicit cooperation between voting blocs with similar but not identical preferences. For several of the preference profiles they study, coordination is consistent with their model a large fraction of the time.

Gerber, Morton, and Rietz (1998) and Morton and Rietz (2008) explore the multi-candidate coordination problem with different electoral institutions. Gerber and others look at cumulative voting when two candidates (rather than one) are to be elected, to see if it can ameliorate problems of minority underrepresentation due to miscoordination.

Voters are endowed with two votes. In the baseline treatment, they can cast one vote for each of two different candidates, only one vote for one candidate, or no votes for any candidate. In the cumulative voting treatment, they have the additional option of casting two votes for one candidate. The top two vote getters are elected. They use the same preference profile as in Forsythe and others (1993, 1996), and payoffs are additive with respect to the two winners of an election. In the baseline treatment, the theoretical prediction is that C will never win, but C should win under cumulative voting. The data closely match the theory. Morton and Rietz consider runoff elections where winning requires a clear majority. If there is no majority winning in the first round, then the two top candidates engage in a runoff election in the second round. This also helps solve the coordination problem in a similar way to polls: whichever of the two minority candidates is in the runoff wins.

To summarize, multicandidate elections are an intriguing and immensely complex brand of coordination problem. Outcomes are extremely sensitive to the fine details of the voting institutions as well as the myriad of coordinating devices related to those institutions (polls, history, party labels, campaign contributions, and even cheap talk). This would seem to be a rich area for both experimental and theoretical research. An obvious direction to explore is to look at the endogenous entry of candidates and endogenous policy positions of candidates. All these experiments fix the number of competing candidates and even fix their policies (except for Plott 1991).

Principal Findings for Multicandidate Elections

1. In the absence of coordination devices, simple plurality rule can lead to poor outcomes (Condorcet losers) in multicandidate elections.
2. Very simple coordination devices, such as polls, publicly revealed campaign contributions, and past electoral outcomes, can help alleviate coordination problems.
3. If a Condorcet winner exists, competitive elections under plurality rule with three candidates converge toward the core point but with more variance than in two-candidate elections.
4. Voting rules other than plurality rule (Borda count, approval voting, runoff, etc.) can outperform plurality rule in specific environments.
5. All the preceding results are based on a very limited set of environments that have been studied in the laboratory.

3.3 Candidate Competition with Valence

In many elections, candidates are asymmetric. A widely cited source of asymmetry is incumbency. It is generally thought that incumbents have a significant advantage over challengers, above and beyond any advantage (or disadvantage) they may have due to spatial location. Other sources of asymmetries include valence characteristics of candidates, such as a familiar name, movie- or athletic-star status, height, articulateness, and personality traits. The two key aspects of these valence characteristics are (1) most voters value them, independent of the candidate platforms, and (2) they are fixed, rather than being chosen by the candidates. With strategic competition, candidate asymmetries have interesting and systematic implications for equilibrium platforms. These asymmetric contests have been studied recently both theoretically and empirically in game theoretic models by Erikson and Palfrey (2000), Ansolabehere and Snyder (2000), Groseclose (2001), Aragones and Palfrey (2002, 2005), and others.

Groseclose (2001) and Aragones and Palfrey (2002, 2005) show that valence asymmetries lead to candidate divergence, even in one-dimensional spatial models. The equilibria, which can be either mixed-strategy equilibria or pure-strategy equilibria (if candidates have policy preferences and there is enough exogenous uncertainty), have two interesting features. First, a disadvantaged candidate will tend to locate at more extreme locations in the policy space than the advantaged candidate.[77] Second, the extent to which this happens depends, in a systematic way, on the distribution of voters. As the distribution of voter ideal points becomes more polarized (e.g., a bimodal distribution), the disadvantaged candidate moves toward the center, while the advantaged candidate moves in the opposite direction and adopts more extreme positions.

Aragones and Palfrey (2004) report the results of an experiment designed to test whether these systematic effects can be measured in a simplified spatial competition environment. Candidates simultaneously choose one of three locations, {L, C, R}. The location of the median voter is unknown, but they both know the distribution. The median is located at C with probability α, and located at either L or R with probability $(1-\alpha)/2$. Candidate 1 is the advantaged candidate; he or she wins if the median voter is indifferent (in policy space) between the two candidates, which happens if the candidates locate in the same position or if one chooses L and the other R. Their main treatment variable is the distribution of the median, α, which in different sessions takes on values of either $\frac{1}{5}$, $\frac{1}{3}$, or $\frac{3}{5}$. The equilibrium is characterized by a pair of probabilities of locating at the central location, one for the advantaged candidate (p) and one for the disadvantaged candidate (q). These equilibrium probabilities are ordered as follows:

$$0 < q_{3/5} < q_{1/3} < q_{1/5} < \tfrac{1}{3} < p_{3/5} < p_{1/3} < p_{1/5} < 1$$

The data perfectly reproduce this ordering of candidate locations for all treatments, and the results are quantitatively close to the mixed-strategy equilibrium-choice probabilities. The result appears to be robust and has been replicated successfully with different subject pools and instruction protocols. There are also now a number of theoretical results when the policy space is continuous instead of discrete (Aragones and Palfrey 2002; Hummel 2010), and a natural "next experiment" in this area would be to run a similar experiment but in an explicitly spatial environment.

Asymmetric contests have also been studied in economics experiments. Perhaps the best known is the study of tournaments rewards, by Bull, Schotter and Weigelt (1987), and interest in studying these asymmetric contests has resurfaced recently in studies that look at the tournament structure of labor markets as a possible reason for gender wage differentials and glass ceilings (Gneezy, Niederle, and Rustichini 2003). It would be interesting to extend this tournament approach to study campaign spending in political campaigns. The problem is also closely related to all-pay auctions, which have received some recent attention by experimental economists.

Principal Findings for Elections with a Valence Dimension

1. In two-way races along one dimension, higher-quality candidates tend to adopt more-moderate positions.
2. This effect diminishes with more polarized distributions of voters.

4 VOTER TURNOUT

Fiorina (1978) dubbed it "the paradox that ate rational choice theory." A typical statement of the paradox is the following. In mass elections, if a significant fraction of voters were to turn out to vote, the probability any voter is pivotal is nearly zero. But if the probability of being pivotal is zero, it is irrational to vote because the expected benefits would then be outweighed by any tiny cost associated with voting. Hence the fact that we see significant turnout in mass elections is inconsistent with rational choice theory. Voters must be voting for some other reasons, and rational choice theory is not a useful approach to understanding political participation.

Palfrey and Rosenthal (1983) take issue with the logic of the paradox. They point out that turnout should be modeled as a "participation game" and that zero turnout is not an equilibrium of the game, even with rather high voting costs. In fact, as the number of eligible voters becomes large (even in the millions or hundreds of millions), they prove the existence of Nash equilibria where two-party elections are expected to be quite close and turnout is approximately twice the fraction of the electorate that prefers the underdog. Thus, in tight races, where there is no clear favorite, equilibrium turnout can be nearly 100%. These high-turnout equilibria also have some other intuitive properties; for example, supporters of the underdog (who face less of a free-rider problem within their group) turn out at a higher rate than the supporters of the favorite.

4.1 Instrumental Voting Experiments

Schram and Sonnemans (1996a) describe results from an experiment designed to not only test the Palfrey-Rosenthal theory of turnout, but also to compare turnout in winner-take-all (W) elections to turnout in proportional representation (PR). They studied 2-party elections with 12, 14, or 28 voters in each election. Voters were equally split between the two parties, except in the 14-voter treatment, where there were 6 voters for party A and 8 for party B. In the PR elections, the cost of voting was 70, and the payoff to all members of party j was equal to $222 \cdot v_j$, where v_j was party j's vote share. In the W elections, the cost of voting was 100 and all members of the winning party received 250, with ties broken randomly. All this was made common knowledge by presenting the subjects with a common set of instructions.[78] Each session ran one of these treatments repeatedly, with feedback, over a sequence of 20 elections. It was not a symmetric experimental design, with most sessions using W elections. There were also some secondary treatments and some additional variations explored in Schram and Sonnemans (1996b). The main findings were as follows:

1. Turnout in the early (inexperienced) W elections started around 50% and declined to around 25% by the last election. The decline was steady, and it's not clear whether it would have declined even further with more experience.
2. Turnout in the early (inexperienced) PR elections started around 30% and declined to around 20% in the last two elections. The decline was very gradual in these elections, and it's not clear whether it would have declined even further with more experience.
3. The effects of electorate size and party size are negligible.

Exactly how to interpret these results is a difficult question. The theoretical predictions of Palfrey and Rosenthal (1983) for the W elections are somewhat ambiguous because there are many equilibria, including pure-strategy equilibria (except in the fourteen-voter case), totally mixed strategy equilibria, and mixed-pure equilibria. In fact, the range of possible equilibrium turnout rates in each of the W games conducted in the experiment includes much of the entire [0, 1] interval. The decline of turnout may indicate that behavior is equilibrating, and might eventually converge to the low turnout totally-mixed equilibrium (between 2% and 5% in the W games), if the experiments could have lasted long enough. But this is highly conjectural. The symmetric equilibrium of the PR game was slightly higher, about 10%. Again, one might conjecture that voter behavior is converging on this equilibrium, but that is also highly speculative, and can only be answered definitively with more experienced subjects (longer sequences of elections), or perhaps an alternative design.

The biggest puzzle in the data is why initial turnout rates in the PR elections were so much lower than initial turnout rates in the W elections. A possible explanation is coordination failure and multiple equilibria. While both voting rules can have multiple equilibria, it is only the W elections for which equilibria exist with high turnout rates (above 50%). One interpretation of these experiments is that the severe multiple equilibrium problems identified by the theory present tremendous strategic ambiguity to the subjects and render the early round data almost useless for evaluating the effect of voting rules and electorate size on turnout.[79]

Levine and Palfrey (2007) take a different approach to addressing comparative statics questions about the effect of electorate size, relative party size, and voting cost on turnout in W elections. Their design follows Palfrey and Rosenthal (1985), which extended their 1983 game-theoretic analysis of turnout to allow for heterogeneity of voting costs and asymmetric information. In that model, all voters in a party have the same benefit of winning, but each voter has a privately known voting cost that is an independent draw from a commonly known distribution of costs. The symmetric equilibrium of these games, with equal-sized parties, is characterized by a simple cutpoint decision rule, where voters with costs less than a critical cost, c^*, vote and voters with costs greater than c^* abstain. For many cost distributions, there is a unique equilibrium cutpoint, so the coordination problem is completely eliminated. The analysis is extended easily to unequally sized parties, with the cutpoints typically different for the two parties.

They conduct an experiment where electorate size can take on values of 3, 9, 27, and 51. Winning pays off 105, losing pays off 5, and a tie pays off 55.[80] Neutral instructions were used, with no mention of voting, winning, or losing. The voting cost was framed as an opportunity cost, the equivalent of an abstention bonus. For each electorate size, N, there are two party-size treatments, called toss-up (T) and landslide (L). In the T treatment, the larger party has $(N+1)/2$ members and the smaller party has $(N-1)/2$ members. In the L treatment, the larger party has $2N/3$ members and the smaller party has $N/3$ members. This produces a 4×2 design.[81] In all elections, there is a unique Nash equilibrium. The comparative statics of the equilibrium in the various treatments are simple and intuitive. Turnout should be decreasing in N for both parties—the size effect. Turnout should be higher for both parties in the T treatment than in the L treatment—the competition effect. Turnout should be higher for the smaller party than the larger party—the underdog effect, with the exception of $N = 3$, an unusual case where the larger party has higher equilibrium turnout.

The aggregate results conclusively support the Nash equilibrium comparative statics. Figure 6.13 compares the observed (vertical axis) upset rates,[82] and close election rates[83] to the Nash equilibrium predictions (horizontal axis) for all the experimental

Figure 6.13: Equilibrium and observed upset rates and close elections.

treatments. The observation/prediction pairs line up almost exactly on the 45% line. A simple linear regression gives an intercept of 0.01, a slope of 1.03, and $R^2 = 0.99$.

Nearly all the predicted qualitative comparative statics results are observed. In fact, all the theoretical predictions about the competition effect[84] and the underdog effect were found in the data. All but one size-effect prediction was observed.[85] The results are also very close quantitatively to the equilibrium predictions, with one caveat. The turnout probabilities are somewhat less responsive to the treatment parameters than equilibrium theory predicts.

These attenuated treatment effects are shown to be consistent with the Logit version of regular quantal response equilibrium (QRE). QRE replaces the assumption of perfect best response to noisy best response. In its most general formulation (McKelvey and Palfrey 1995, 1998), this is modeled by adding privately observed payoff disturbances associated with each strategy of each player and at QRE is defined as a Bayesian equilbrium of a game in which the joint distribution of all these additive payoff disturbances is common knowledge. In all applications to date, it is assumed that the disturbances for each individual are i.i.d., which implies that response functions are simply smoothed out best response functions, with the choice frequencies of strategies by each player monotone in expected payoffs.[86] A *regular* QRE is a fixed point of these smoothed-out monotone-response functions, just as Nash equilibrium is a fixed point of best-response correspondences. A relatively tractable parametrization uses Logit response functions, where the probability player i chooses strategy s_{ij}, p_{ij} is given by

$$p_{ij} = \frac{e^{\lambda U_{ij}(p)}}{\sum_{s_{ij} \in S_i} e^{\lambda U_{ij}(p)}}$$

where $\lambda \in [0, \infty)$. Then p^* is a Logit QRE (sometimes called a Logit equilibrium) of a particular game for a particular value of λ if and only if, for all $i,\ j$,

$$p^*_{ij} = \frac{e^{\lambda U_{ij}(p^*)}}{\sum_{s_{ij} \in S_i} e^{\lambda U_{ij}(p^*)}},$$

Thus, for any game, the Logit specification defines a family of quantal response equilibria parameterized by λ. When $\lambda = 0$ players are completely payoff unresponsive and choose all strategies with equal probability. Limit points, when $\lambda \to \infty$, are Nash equilbria, although not all Nash equilibria can be approached by a sequence of Logit QRE.[87] For this reason, Logit QRE provides a method of selecting among Nash equilibria. In fact, for almost all games there is a unique selection from the Nash equilibrium, called the Logit solution of a game, defined as the unique limit point that is connected in the graph to the $\lambda = 0$ equilibrium. In many games, the Logit equilibria imply definitive comparative statics or directional biases from Nash equilibrium choice probabilities.

Voter-turnout games provide a convenient illustration of how such biases can arise, even though the payoff disturbances to the players that underly the Logit model are completely unbiased. In particular, the Logit QRE of these games predicts *higher turnout than the Nash predictions for large electorates* and *lower turnout in the* $N = 3$ *treatment*. Levine and Palfrey (2007) use their data to estimate one free parameter of a Logit QRE model, λ, based on their entire dataset. Then, based on this estimate, they can extrapolate to what turnout would be in mass elections with hundreds of millions of potential voters. Such an exercise implies that, for plausible distributions of voting costs, equilibrium turnout rates in the Logit QRE model are on the same order of magnitude as what we observe in nationwide elections in the United States. Since 1970, turnout in US national elections as a percentage of the voting-age population has ranged from 49% to 55% in presidential elections and 36% to 47% in midterm elections. If the voting costs were positive for all eligible voters and uniformly distributed and the value of being a dictator in the election (i.e., the benefit of unilaterally changing the election outcome from your least preferred candidate to your most preferred candidate) is, for the average voter, 100 times the cost of voting, then QRE expected turnout—based on the Logit parameter estimate in the paper—in large elections is approximately 48%.

Furthermore, the Logit specification of stochastic choice also turns out to fit the individual choice data remarkably well. The stochastic choice model specifies that the probability a voter votes in a given treatment is a smooth and continuously decreasing function of voting cost and is anchored by the treatment-specific equilibrium cutpoint (i.e., the point where a voter is indifferent between voting and abstaining given the other voters' turnout strategies). At such an indifference point, the stochastic choice model predicts that the voter is equally likely to vote or abstain. Figure 6.14 shows the turnout rates as a function of normalized[88] voting costs, including all treatments pooled together. The points in the figure indicate the observed turnout frequency for a particular treatment and party at each normalized voting cost, with horizontal bars indicating the overall average turnout at 0.03 intervals. The solid decreasing curve is the Logit choice probability function at the QRE for the estimated value of $\lambda = 7$.

Goeree and Holt (2005) apply a QRE analysis of symmetric equilibria for a broad range of symmetric complete information game-theoretic models of participation. They consider the class of games where N players each have a binary choice (participate

Figure 6.14: Turnout rates and normalized voting costs.

or not), and the expected payoffs to a player for participating or not are given by $P(p, N)$ and $NP(p, N)$, respectively, if all $N - 1$ other players are participating with probability p.[89] Examples of such games include variations on threshold public goods games (van de Kragt et al. 1983; Palfrey and Rosenthal 1984, 1988, 1991a, 1991b, 1994), the volunteer's dilemma (Murnighan et al. 1993; Diekmann 1985), voter turnout (Palfrey and Rosenthal 1983, 1985), congestion games, and strategic entry in markets (Sundali et al. 1995). Goeree and Holt's analysis organizes a wide range of observed behavior in experiments, including some that had been considered anomalous from the standpoint of traditional Nash equilibrium theory.[90]

A particularly relevant result for the present survey is the application by Goeree and Holt (2005) of the QRE approach to the Schram and Sonnemans (1996) voter-turnout studies described at the beginning of Section 4.1. First, as in the Levine and Palfrey (2007) analysis with respect to voter-turnout games with private information, QRE turnout rates are biased toward 50%, compared to the Nash equilibria. Goeree and Holt demonstrate this is also true for complete-information voting games, using the low-turnout symmetric equilibrium as the relevant benchmark. For relatively low levels of λ (e.g., high error rates by inexperienced players), they show that turnout will be higher for W elections than in PR elections, but for higher values of λ the differences are smaller and for some parameter values completely disappears. Moveover, for both voting rules turnout rates decline monotonically in λ. All three of these properties are mirrored in the Schram and Sonnemans study, as noted earlier.

The approach of modeling turnout as a Bayesian game with privately known voting costs has recently been extended to compare turnout in PR versus W electoral systems by Herrera, Morelli, and Palfrey (2014) and Kartal (2013). Theoretically it is shown that equilibrium turnout is generally higher in W if the election is competitive and higher in PR if the election is a landslide. The intuition is that turnout in W is highly responsive to expected closeness, while turnout in PR is not. The experiments reported in those papers provide qualified support for this. This provides yet another alternative explanation for the higher turnouts in PR elections that were reported in Schram and Sonnemans (1996a,b), although costs were homogeneous and common knowledge in that experiment.[91]

4.2 *The Effects of Beliefs, Communication, and Information on Turnout*

Duffy and Tavits (2008) conduct an experiment based on the complete information Palfrey and Rosenthal (1983) model that, in addition to observing turnout decisions by individual voters, also elicits beliefs from individual voters about the probability of a close election, using a proper scoring rule. The objective of the design is to have a more direct test of the pivotal voter hypothesis and allow one to sort out possible deviations from equilibrium, depending on whether they are due to incorrect beliefs about the probability of being pivotal or other sources that have been hypothesized, such as expressive voting (discussed shortly). The former can be measured by comparing the belief about being pivotal to the empirical distribution of margin of victory; the latter can be measured by comparing a voter's actual turnout choice with the turnout choice that would be optimal given the voter's beliefs about being pivotal. Regarding the former, they find that voters' reported beliefs about the probability of a close election are generally higher than the actual frequencies in the experiment, although the bias in beliefs declines significantly with experience. Regarding the latter, they find that turnout rates are positively correlated with reported beliefs about pivot probabilities, as one would expect. However, voters systematically turn out much *less* frequently than they should, given their beliefs. In fact, they also vote less than what would be optimal if they actually held empirically accurate beliefs or even if they had the equilibrium beliefs.

There are a number of possible explanations for these apparently contradictory findings. On the one hand, if subjects are risk neutral, then either they are clearly not optimizing given their beliefs or the belief elicitation procedure failed.[92] An alternative explanation is risk aversion, which would have (at least) two effects in their experiment. First, risk aversion would bias reported beliefs upward in the direction of 0.5 under the Brier scoring rule. Second, risk aversion would lead to reduced turnout, since voting results in a certain loss in exchange for an uncertain gain. In any case, the data clearly cast some doubt on the notion that nonnegligible turnout rates in mass elections are mainly due to voters overestimating the probability of being pivotal.

Grosser and Schram (2010) also use the 1983 Palfrey-Rosenthal participation game model as the basis for their study of the effect of preelection polling on turnout. In their design, laboratory electorates of size 12 are divided into two parties of relative sizes 9–3, 8–4, 7–5, 6–6, 5–7, 4–8, or 3–9. The main treatment variable is whether or not voters are informed about the exact relative sizes of the parties (the "polling" treatment) or only told the probability distribution of these relative sizes.[93] There was no additional private information beyond a voter's knowledge of his or her own party preference. Benefits and costs were the same for all voters, and this was common knowledge. They find that many of their results are well explained by the Logit QRE. The two main findings are (1) that polling led to higher turnout on average, with the greatest effect being when voters were informed the party split was 6–6, and (2) that, with full information, turnout was higher in more competitive elections. The second effect was not just due to higher turnout in the 6–6 cases. However, the first effect is entirely driven by the 6–6 cases. This could be due to multiple equilibria, as 100% turnout is a second symmetric Nash equilibrium in the 6–6 elections.

In a second study of informational effects on turnout, Grosser and Schram (2006) study the role of information about other voters' turnout decisions.[94] In particular, they are interested in identifying whether knowledge of other voters' turnout decisions can affect a voter's turnout decision. This could have potentially important ramifications for election policies such as early voting and news delays on exit polls and election day returns. They do so in a similar complete-information 6–6 voter-turnout game, but half of the voters in each party are "early" voters and the remaining late voters can observe some information about the early voting before deciding whether or not to vote.[95] There are three different information treatments. In the baseline, late voters are given no information. In the second treatment, late voters are told the turnout decision of exactly one of the early voters but are not told which party that voter belonged to. In the third treatment, late voters are told the turnout decision of exactly one of the early voters and also told to which party that voter belonged. In the last treatment, the early voters are told in advance whether their vote would be observed by a member of the same party or a different party. Each late voter is told about one early voter's turnout decision. Cases are distinguished where the voters are allies (support the same group) or adversaries (with opposing preferences) and where they are uncertain about each other's preferences. From the quasi-symmetric equilibrium Grosser and Schram solve for, two key hypotheses emerge. First, information of this kind is predicted to increase overall turnout. Second, turnout rates for early voters are higher than for late voters, largely because early voters may vote in *either* stage.[96] Both comparative static predictions are borne out in the data; however the turnout rates for either kind of voter in nearly all the treatments is very far from the equilibrium levels. This is probably due to the fact that the game is plagued by multiple equilibria.[97] Even the no-information game has two quasi-symmetric equilibria ranging in turnout from 10% to 90%.[98]

4.3 Expressive Voting Experiments

Finally, there is a small literature designed to test the hypothesis that some voters vote expressively. That is, rather than voting to affect the outcome, they vote as an expression of what is the right thing to do. These are, in fact, complicated public goods problems. In all these experiments, one of the two outcomes is socially beneficial, while the other outcome maximizes private benefits. As in public goods experiments, the private monetary benefits are induced by the experimenter, but the social utility of subjects from the outcomes is not controlled for. Costs are controlled indirectly by implementing treatments that differ in the probability a vote will be pivotal. However, just as in standard turnout models, the probability a vote will be pivotal is endogenous and depends on other players' social utility as well as other players' expectations about other players, and so on.

The basic idea, due to Tullock (1971), is that some people who would prefer not to contribute to the public good may indeed by willing to vote (expressively) in favor of the socially good outcome if they believe their vote is unlikely to be decisive. By doing so, they can express a socially good view at low expected cost, the "low-cost hypothesis." The comparative static of interest is whether the probability of voting for the socially good outcome decreases in the pivot probability.[99] Various experimental designs have been exploited with mixed results.

Several studies have looked at quorum elections, where everyone in the group is forced to contribute and the proceeds are donated to a charity if and only if the number of yes votes exceeds the specified quorum.[100] The initial study was by Carter and Guerette (1992), and they found weak support for expressive voting with one parameter set and no support for their other treatment, using an individual-choice design, where the experimenter manipulated beliefs about pivot probabilities. Tyran (2004) conducted experiments with a large numbers of subjects (220) and different voting thresholds (quorums) and elicited beliefs about subjects' expectations that the quota would be met or exceeded rather than directly manipulating pivot probabilities.[101] He finds a lot of heterogeneity across the voters. Approximately 60% of the voters are purely instrumental, and either always vote yes or always vote no for all quorums. The remaining voters, however, mostly do not exhibit behavior that is consistent with the low-cost hypothesis. The authors suggest alternative explanations of their behavior in terms of bandwagon effects or conformist behavior, observing that subjects tended to be more likely to vote yes when they report beliefs that the proposal is more likely to pass.[102] Fischer (1996) finds some support for the low-cost hypothesis, but the experiment is less controlled; it was conducted as a classroom exercise by the lecturer, and group sizes were not carefully controlled.

Feddersen et al. (2009) conduct an experiment closer to the standard costly voting designs discussed earlier in this section. There were N_A voters in favor of A, N_B voters in favor of B, and a subset n of the B voters were designated as active. Only the active B voters were allowed to vote. They decided simultaneously to either vote for A, vote for B, or abstain. Voting for one of the alternatives resulted in a voting cost, c. One of the n active B voters was then selected and the outcome was determined by that voter's vote. If they abstained the outcome was determined by a coin toss. Thus, the pivot probability is directly controlled by varying n. Also, note that the pivot probability is *exogenous* and doesn't depend on the other active voters' decisions. In all cases, $N_A > N_B$ and A voters have more intense induced preferences, so a selfish vote by a B voter is to vote for B and an ethically expressive vote is for A, the group payoff maximizing outcome. They find (1) average turnout about 40%, with somewhat more selfish than ethical voting; (2) insignificant responses of ethical voting to pivot probabilities; (3) large and significant effects of the pivot probability on selfish voting; and (4) the probability of voting selfishly decreases in N_A, with no effect of N_B. In summary, this study is the cleanest laboratory study yet of expressive voting, but it finds mixed results. The fact that there is nearly as much A voting as B voting suggests there is some degree of ethical voting, but failure of a number of predicted comparative statics cast some doubt on the theory as a useful predictor (or explanation) of how voting outcomes respond to changes in the underlying driving variables such as voting cost, relative party size, and electorate size.

Principal Findings for Voter Turnout

1. In experiments with direct costs of voting that are private information (e.g., Levine and Palfrey 2007; Herrera, Morelli, and Palfrey 2014; Duffy and Tavits 2008), many of the comparative statics predictions of the game theoretic instrumental voting model are observed in the data. This includes the size effect, competition effect, and underdog effect. The bottom line is that voters are more likely to vote when they are more likely to be pivotal or believe they are more likely to be pivotal.
2. In most studies there is higher turnout than is predicted in equilibrium with purely instrumental voting.

3. The Logit quantal response equilibrium model accounts for much of the observed overvoting and also the occasional observations of undervoting.
4. Experimental studies have found important differences in aggregate turnout between proportional representation and winner-take-all elections, and these differences are qualitatively consistent with instrumental voting theory.
5. The low-cost hypothesis about expressive voting over charitable contributions, proposed by Tullock, has relatively little support in the data.

5 INFORMATION AGGREGATION IN COMMITTEES

The earlier sections of this chapter discussed experiments designed to address questions of preference aggregation. Given a feasible set of policies, a profile of preferences of the political actors (voters, legislators, etc.), and a political institution, what outcomes will result? Then, as we vary the profile of preferences and the feasible set of policies, fixing the political institution, a picture emerges about how that particular political institution transforms diverse preferences into social choices.

This section discusses experiments aimed at understanding an equally important set of questions in social choice theory: how political institutions aggregate the diverse private information of the political actors. While in some cases the aggregation of preferences and information interact in complex ways, most of the political economy research on information aggregation has focused on the pure common values case. The political actors are like minded and thus have identical preferences, and they must decide on a policy where the payoff is uncertain and depends on the state of the world. Although the state is unknown, each actor has some private information about the state of the world. Thus, not only does the committee have limited information about the payoff relevant state, but this information is dispersed across the actors. How do different political institutions pull this information together into a collective decision? Because individuals have identical preferences, one can make unambiguous welfare comparisons across institutions if some institutions lead to more informative decisions than others. That is, in this class of models, an institution is better the more successfully it reflects all of the dispersed information.

5.1 Condorcet Jury Experiments

Marquis de Condorcet was the first to formally address this question, and he presented a mathematical argument for the superiority of majority rule as way to aggregate dispersed information when everyone has common preferences. His very simple voting model, the Condorcet jury model (CJM) has survived for more than two centuries and is still *the* workhorse model of information aggregation in political science. There are two equally likely states of the world, a and b, and each voter (juror) has a privately known clue (or hunch) as to which state of the world is more likely, in the form of a binary signal, α or β. The voters must collectively decide on one of two possible policies, A and B, where all voters prefer A in state a and B in state b. If the individual clues are at all informative (e.g., $\text{pr}\{\alpha|a\} = \text{pr}\{\beta|b\} = q > 0.5$), then—all voters voting for the policy they personally think is best given their private information—the probability that a majority rule vote will result in the correct decision goes to 1 as the number of voters becomes large. The result is a simple example of the law of large numbers.

A watershed paper by Austen-Smith and Banks (1996) raises serious questions about Condorcet's implicit assumption that all voters will vote naively, that is, vote as if they were the only voter. They formally recast the CJM as a voting game and study the properties of the Nash equilibria of the game. They show that the common assumption of naive voting is generally inconsistent with equilibrium behavior. Instead, the equilibrium of the game can be quite complicated and can lead to counterintuitive and perverse results. These equilibrium voting strategies are quite sensitive to the details of the voting procedure as well. The main insight is that since optimal voting behavior follows a pivotal voter calculus,[103] a voter's equilibrium posterior over the states depends not only on his or her private signal, but also on the information implied by the event that he or she is a pivotal voter; and that information depends on the strategies of the other voters. However, the logic and the cognitive requirements of equilibrium behavior are daunting, so this raises the behavioral question of whether voters vote naively/sincerely or vote according to the equilibrium pivotal calculus. The answer has significant implications for the aggregation of information in voting rules because full information aggregation in the limit may not be a property of plausible Nash equilibria, even when it is a property of naive voting.

Guarnaschelli, McKelvey, and Palfrey (2000) is the first published laboratory study of behavior in CJM voting games with information aggregation.[104] The paper is based on Feddersen and Pesendorfer's (1998) analysis of strategic voting under unanimity rule, with a default status quo. That is, outcome A occurs unless all voters (jurors) vote for B. The motivating example is the commonly used voting rule for juries in criminal trials in the United States. The defendant is convicted if and only if all jurors vote for conviction, otherwise he goes free.[105] So, a corresponds to innocent, b to guilty; A corresponds to acquit and B to convict; α corresponds to a private signal indicating probably innocent and β, probably guilty.

The standard justification for unanimity rule is to protect the innocent: that it reduces the probability of a "bad" error, where an innocent defendant is convicted, possibly at the expense of increasing the probability of the "less-bad" error of acquitting a guilty defendent. Feddersen and Pesendorfer's (1998) remarkable result is that, in equilibrium, *the unanimity rule in juries has the opposite effect of the intended one*: Nash equilibrium may lead to a higher probability of convicting the innocent than subunanimity rules, including majority rule. In particular, it is generally not a Nash equilibrium for all voters to just follow their own signal. Put yourself in the position of a voter with an innocent signal (α), and think about how you should vote if you believe everyone else on the jury is voting according to their signal (vote A with an α signal and B with an β signal). Your vote makes a difference only when your vote is pivotal, which—because of the unanimity rule—occurs only if all other voters vote B. But that means that collectively the jury must have received $n-1$ private β signals and just a single α signal (yours). Given this information, the state of the world is much more likely to be b than a, so your optimal vote is B (convict). Therefore, it is not a Nash equilibrium for everyone to vote their signal. The only way any information at all can be aggregated in a symmetric Nash equilibrium must have some fraction of voters with α signals voting for B—a mixed strategy. The strategic incentive for voters with a β signal are not adverse, so they all vote according to their signal. Hence, in equilibrium the voters will adopt strategies that (partially) cancel out the A-bias of the voting rule.

Note that, according to this equilibrium logic, the adverse incentive effect to vote B with an α signal becomes *stronger* as n increases. Therefore, the problem is not overcome by having larger juries; on the contrary, this problem can be worse in large juries than small juries. This directly contradicts the standard jurisprudential argument both for unanimity rules and for relatively large (twelve-member) juries. Naive intuition suggests that raising the hurdle for conviction will reduce the chances of a false conviction. But that intuition relies on an assumption that voting behavior is unaffected by the voting rule or the jury size: voters are assumed to be nonstrategic and just vote according to their own personal signal, as if there were no other voters. Game-theoretic reasoning says the opposite: when the hurdle for conviction is raised, voters are less willing to vote to acquit.

There are a number of reasons to second-guess the behavioral predictions of Nash equilibrium in this voting game. First, if legal scholars and brilliant minds like Condorcet believe voters will be sincere, then how could one expect the average voter to be smarter and realize that this simple intuitive reasoning is flawed? Second, logic requires voters to condition on hypothetical events—the event that one's vote is pivotal. The strategic pivotal calculus of Nash equilibrium is extremely complicated, and its computation requires repeated application of Bayes' rule, conditioning on low-probability hypothetical events (pivot probabilities), and expectations that other voters are also doing these calculations. There is abundant evidence from economics and psychology that judgements of low-probability events are flawed, that individuals update beliefs in ways that often systematically violate Bayes' rule, and that they poorly understand how to condition probabilities on hypothetical events. Third, as it turns out these equilibria typically involve the use of mixed strategies, and laboratory data exist in other contexts indicating (1) individuals find it difficult to implement mixed strategies and (2) Nash equilibrium is often a poor predictor of behavior in games with mixed-strategy equilibria, even when the equilibrium is unique (Ochs 1995).

As if three reasons were not enough to justify an experiment, there was an additional fourth reason that motivated the experiment of Guarnaschelli, McKelvey, and Palfrey (2000). Logit quantal response equilibrium and Nash equilibrium make drastically different qualitative and quantitative predictions about the effects of jury size and voting rule on the probability of correct jury decisions, especially for large elections. The limiting result about the accuracy of jury group decisions in Feddersen and Pesendorfer (1998) is a knife-edge result that depends on 100% rationality of the voters. With stochastic choice, the standard jurisprudential arguments reemerge as properties of the quantal response equilibrium: (1) majority rule leads to more false convictions than unanimity in large juries, and (2) larger unanimous juries produce fewer false convictions than smaller unanimous juries.

The experimental design was $2 \times 2 \times 2$, where the treatments varied according to (1) *jury size*—three or six, (2) *voting rule*—majority or unanimity,[106] and (3) *preplay communication*—straw poll or no straw poll. For all treatments in the design, the two states were equally likely a priori and signal informativeness was $q = 0.7$. A within-subject design was employed with respect to the voting rule and the straw poll. That is, in each session of the experiment, the jury size was fixed, but subjects participated in an equal number of committee decisions under both majority and unanimity rule and with and without a straw poll. This was done by dividing each session into a sequence of four parts, with fifteen repetitions of each part with random matching. Four sessions were run, each with twelve subjects.

The central finding was that voters do indeed vote strategically in juries that operate under a unanimity requirement. In the unanimity committees that operated without a straw vote, essentially all β signal voters vote for B and a large fraction of α signal voters also vote for B rather than following their signal. Moreover, the fraction of α signal voters who vote for B rather than following their signal was significantly higher in the six-person committees than in the three-person committees. The proportions are given

TABLE 6.2:
Proportion voting for B, by signal.

U	Voter Signal		M	Voter Signal	
n	α	β	n	α	β
3	0.36	0.95	3	0.06	0.97
6	0.48	0.90	6	0.21	0.98

TABLE 6.3:
Proportion of incorrect committee decisions in state b.

Unanimity			Majority		
n	No Straw Vote	Straw Vote	n	No Straw Vote	Straw Vote
3	0.53	0.36	3	0.30	0.19
6	0.73	0.44	6	0.21	0.11

in left panel of Table 6.2. In contrast, under majority rule, voters without a straw poll voted their signal more than 94% of the time (right panel).[107]

The second finding was that the straw vote led to significantly better information aggregation under both voting rules. It is easy to show that under unanimity rule, it is an equilibrium for voters to vote sincerely in the straw-vote stage and then follow the majority outcome of the straw vote in the binding-vote stage. Nearly all the gains occur in the b state, because with a straw vote nearly all α signal voters also vote for B rather than following their signal if B won the straw vote. Table 6.3 compares the proportion of incorrect committee decisions in state b for all the treatments.

In other words, the straw-vote stage converts the unanimity mechanism into what is essentially a majority voting rule. This is what was observed in the data. Voters voted their signal over 95% of the time in the first stage and followed the straw-vote majority about 85% to 90% of the time in the second binding-vote stage.

Third, the predictions of QRE capture several of the main features of the data, both with respect to comparative statics and quantitatively, while many of the Nash equilibrium comparative static predictions about committee decisions fail.[108] But the main takeaway from the experiment is what the data say about the three "obvious" reasons to be suspicious of the Nash equilibrium behavior. (1) Do voters follow the same naive intuition as legal scholars and great thinkers? No, it is something in between Nash equilibrium and naive play. Most voters respond strategically to the voting rule; but their response has a significant stochastic component. (2) Is the strategic reasoning too complicated for voters in the laboratory to behave according to theory? No, their behavior indicates that they understand the basic incentives, although they do not perfectly best respond. Variations in strategic behavior can be approximated by the Logit version of QRE. (3) Does the fact that equilibrium is in mixed strategies lead to problems? No. In fact, QRE assumes that behavior is inherently stochastic and accurately predicts the probability distribution of aggregate behavior. Analysis of individual behavior in these experiments uncovers a wide diversity of patterns of individual choice behavior. Aggregate behavior is consistent with the interpretation of mixed strategy equilibria (or QRE) as an "equilibrium in beliefs."

Others have investigated variations on this basic jury experiment. Ali and others (2008) conduct an experiment that does two things. First, it demonstrates the robustness

TABLE 6.4:
Proportion voting for B, by signal. Number of observations in parentheses. *Source*: Ali et al. (2008).

U	*Voter Signal*	
n	α	β
3	0.35 (382)	0.94 (338)
6	0.52 (616)	0.94 (464)

of the results about strategic voting of Guarnaschelli, McKelvey, and Palfrey (2000) by conducting a new experiment with the same basic environment but with much different implementation in terms of experimental protocol and procedures. Ali and others use repeated matching (standing committees) rather than random matching (ad hoc committees), use a signal informativeness of $q = \frac{2}{3}$, employ a between-subject design rather than a within-subject design, use a different computer program, with a much different interface, computerize all the randomizations,[109] computerize the (much shorter) instructions, and use a different subject pool and laboratory. They do not have any straw votes and report results only for unanimity rule. The Nash equilibrium probability of voting for B given an α signal is 0.32 for $n = 3$ and 0.66 for $n = 6$. The empirical proportions voting for B in the experiment are given in Table 6.4.

Ali and others (2008) also test theories of equilibrium bandwagon effects[110] by observing voting behavior in committees that operate under sequential voting rule, where later voters are able to observe the votes cast by earlier voters. They provide some weak evidence of bandwagon effects, but the overall effect on voting outcomes is relatively small. The main difference is that sequential voting produces more B outcomes (i.e., unanimous verdicts) than simultaneous voting. As a result the probability of a correct decision in the a state is lower with sequential voting and the probability of a correct decision in the b state is higher. Hung and Plott (2001) also look at majority juries that vote sequentially rather than simultaneously and obtain similar results to Guarnaschelli, McKelvey, and Palfrey (2000).

Goeree and Yariv (2010) successfully replicate and significantly extend Guarnaschelli, McKelvey, and Palfrey (2000). In particular, the paper explores more deeply the earlier finding that straw votes improve information aggregation in laboratory Condorcet jury games. They allow richer preplay communication[111] than the simple binary message preplay communication of a straw vote, consider preference configurations that are heterogeneous, and compare voting behavior in committees operating under three different voting rules ($\frac{5}{9}$, $\frac{7}{9}$, and $\frac{9}{9}$). They find that their richer message space leads to much greater improvements in information aggregation than was observed in the Guarnaschelli and others' study. Voters generally reveal their signal to all other committee members during the chat stage. The results also relate to the theoretical paper of Gerardi and Yariv (2007), which shows that if one allows for unrestricted communication, then nearly all voting rules generate the same set of equilibrium outcomes; in particular, they can lead to higher efficiency.[112] Goeree and Yariv (2010) find that their three different voting rules produce very similar outcomes, suggesting that there is some deeper equilibrium selection criterion that applies to all voting rules with unrestricted communication. To the extent that these information aggregation problems are largely common-value coordination games, then efficiency seems like a natural selection criterion that would apply with roughly equal force to all these voting games with communication.

Dickson, Hafer, and Landa (2008) explore the effect of preplay communication, or deliberation, in a three-person committee voting experiment where voters have signals about the true state of the world and preferences have both a private- and a common-value component. Incentives to communicate are more complex in this environment because the voters have different state-contingent preferences. They find that deliberation induces more information transmission than the equilibrium predictions would sugggest. This finding is similar to results of previous studies based on the Crawford-Sobel model of strategic information transmission (Dickhaut et al. 1995; Cai and Wang 2006) but in a much different setting with less-structured communication.

Morton and Williams (1999, 2001) report experiments that are a hybrid of the Hung-Plott sequential elections and earlier experiments described earlier on multicandidate elections. Just as polls can serve as a coordination device for voters, so can sequential elections. Indeed, this is exactly the idea behind bandwagons in primary campaigns. Voters of the same party converge on the candidate who seems most likely to win in the general election (ceteris paribus). Different voters have different information, or "hunches," about the electability of the candidates, so the question is whether this information is gradually aggregated over sequential elections. Their experiments show that voters do indeed learn from earlier results.

All the preceding studies explore models where voting is costless. Following Battaglini (2005), Battaglini, Morton, and Palfrey (2008a) compare sequential and simultaneous voting in Condorcet jury games, when voting is costly and each voter chooses between voting for A or B or abstaining. In this case the efficiency question revolves around more than just information aggregation. Voting costs are also relevant. A committee's objective is to reach the best decision at the lowest cost. The study uses three-person committees. Ties were broken randomly. There was a high-cost treatment and a low-cost treatment. All voters had the same costs, and signal informativeness was $q = 0.75$. Each subject participated in twenty repetitions of one of the sequential voting games (high or low cost) and twenty repetitions of one of the simultaneous voting games, with random matching.

The simultaneous voting games were conducted much like in Guarneschelli and others (2000) but with the added twist of a voting cost and the opportunity to abstain. Observed turnout was higher in the low-cost treatment than the high-cost treatment, as expected. However, there were significant departures from the symmetric equilibrium. In the high-cost treatment, the observed turnout rate (32%) was significantly above equilibrium (11%). In the low-cost treatment, the observed turnout rate (61%) was significantly below equilibrium (100%).[113]

The equilibrium in the sequential game was quite a bit more complicated. There can be two kinds of equilibria. For sufficiently low-cost voting, the equilibrium is for the first voter to vote; the second voter votes only if he or she received a signal opposite of how the first voter voted and abstains otherwise; the third voter votes only to break a 0–0 or 1–1 tie.[114] For sufficiently high cost, the first and second voters abstain and the third voter votes. Thus, with low costs, the early voters bear more of the voting costs, and with high costs, the later voters bear the voting costs, so there are opposite implications about turnout "trends" over the voting sequence as well as implications about equity. The results are qualitatively similar to the theory, in the sense that for almost all information sets voters abstain most of the time when that is their equilibrium action and vote most of the time otherwise.

However, like the simultaneous voting game, there is quite a bit of noise in the data.[115] With this in mind, the Logit QRE model was fit to the data. Fairly close fits are obtained in both the sequential and the simultaneous voting games, constraining the λ estimates to be same across cost treatments (or fitting one cost treatment using the out-of-sample estimate obtained from the opposite cost treatment). The paper also compares both the informational efficiency (probability of a correct decision) and economic efficiency (taking into account voting costs) between simultaneous and sequential voting methods.[116] With respect to both kinds of efficiency, the sequential voting method is slightly more efficient but most of the differences are either not significantly different from zero or significant but small in magnitude. In both cases, as expected, there is little difference in informational efficiency and somewhat greater difference in economic efficiency.

Principal Findings for Condorcet Jury Experiments

1. Most voters vote strategically in the laboratory in ways that are qualitatively similar to equilibrium models of Condorcet juries with noisy best response.
2. There are strong and significant differences in voting behavior between simultaneous voting procedures and sequential voting procedures. However, the differences in efficiency are relatively small, with sequential voting procedures somewhat more efficient, especially if voting is costly and abstention is allowed.
3. Preplay communication in the form of either straw votes or deliberation, increases efficiency, and such communication reduces or eliminates the effects of different voting rules.

5.2 The Swing Voter's Curse

The swing voter's curse is an especially interesting application of the Condorcet jury model. If voters are differentially informed (i.e., some are better informed than others), then even when voting is costless, abstention is a relevant equilibrium phenomenon. It's fairly easy to see why. Suppose you and your two roommates have identical preferences over movies, but it is common knowledge that only you actually know the content of two possible movies, A and B, that are playing in your local theater, and you have all decided to go out. Your roommates, with no information at all, have a prior belief equal to 0.50 that A is better. Being a democratic group, you vote on everything but anyone can abstain if they want. What is the equilibrium of the majority voting game where ties are broken randomly? You, with full information, vote for the movie you prefer, and your roommates abstain. They can't possible gain by voting, and if one of them votes for the movie you don't vote for, then your group goes to the wrong movie with probability 0.50. In other words, a poorly informed voter *reduces* his or her own utility by being pivotal. That is the simplest example of the *swing voter's curse*.

That was easy. Now suppose instead that your roommates share a common prior belief of 0.99 that A is better. Wouldn't they be better off voting for A? No. The preceding argument is independent of the prior beliefs of the uninformed voters. They should still abstain. Next consider a variation on this. Suppose that one of your roommates, Ann, has different preferences and always prefers to go watch a comedy rather than any other type of movie, regardless of how corny the comedy happens to be; and suppose A is a comedy. The other roommate, Bill, has preferences just like you and wants to go to

TABLE 6.5:
Voting behavior of uninformed voters.

n	A	B	abs
		$\pi = \frac{1}{2}$	
7	0.00	0.08 (0.00)	0.91
9	0.06	0.43 (0.36)	0.51
11	0.04	0.77 (0.76)	0.19
		$\pi = \frac{5}{9}$	
7	0.20	0.07 (0.00)	0.73
9	0.12	0.35 (0.33)	0.53
11	0.16	0.56 (0.73)	0.28

whichever movie is "better." What is the equilibrium now? It is perhaps a bit unintuitive, but the equilibrium has you voting for the movie you "know" is better, Ann votes for A, and Bill votes for B (even though his prior belief is very strongly in favor of A). He votes for B because it ensures that *you* will cast the pivotal vote. This phenomenon can be called *vote balancing*.

Feddersen and Pesendorfer (1996, 1997, 1999) are theoretical papers that explore the equilibrium properties of the swing voter's curse and its implications in regard to patterns of abstention and information aggregation in committees and in large elections. Battaglini, Morton, and Palfrey (2010) conduct the first experimental test of this theory, which (like the preceding example) can have rather unintuitive voting strategies. That study considers committees with seven, nine, and eleven members. Seven of the voters are just like voters in the standard jury problem with identical preferences and just want to choose the better outcome, which depends on the state). In the nine-member committee, there are also two *partisans*, who, like Ann, prefer outcome A regardless of the state; in the eleven-member committees, there are four A-partisans. In the experiment, the partisan's votes are automated by a computer so they always vote for A. The remaining seven human subjects then independently draw a signal. With probability $\frac{1}{4}$ a signal is perfectly informative, and with probability $\frac{3}{4}$ a signal is completely uninformative. Voters observe only their own signals, so they don't know how many (if any) of the other subjects are informed. In one series, subjects all start out with a prior belief of $\pi = \frac{1}{2}$ on state A; in the other series, the prior is $\pi = \frac{5}{9}$. As in the model, the information structure is common knowledge. In the seven-voter committees, the equilibrium is just like the simplest example given earlier. For both of these prior beliefs, only informed voters should vote, and all other voters should abstain. In the nine- and eleven-voter committees, the uniformed voters should balance by mixing between abstention and voting for B. In each session, the prior is fixed for the whole session, and subjects engage in thirty elections—ten each with seven, nine, or eleven voters in the committee—using a random matching protocol.[117]

The observed voting frequencies of uninformed voters are given in Table 6.5. Equilibrium probabilities of voting for B are in parentheses.

All the comparative static predictions of the theory are supported. More partisans lead to more balancing, with less balancing if the prior state probability is biased toward the partisans. With $\pi = \frac{1}{2}$ the results are very close to the theory. Very few uninformed voters succumb to the swing voter's curse in this series (about 5% of votes overall). However, in the series with a biased prior, $\pi = \frac{5}{9}$, a nonnegligible fraction of voters succumb to the swing voter's curse by voting for A. There is also a fair amount of learning, with cursed voting declining significantly with experience.

In a followup study, Battaglini, Morton, and Palfrey (2008b) conduct a replication with larger committees ranging from $n = 17$ to $n = 33$, including up to twelve partisans. The results scale up fairly well, including the comparative statics on the number of partisans and the finding of 10% to 20% cursed voting behavior in the $\pi = \frac{5}{9}$ series. One minor difference is that in one session (with twenty-one human voters) there was a surprising amount of cursed voting (around 20%), including in the elections with no partisans. However, there were only four sessions conducted in total, and no random rematching between elections, so the effective sample size is not very large.

Morton and Tyran (2011) observe that there can be multiple equilibria in voting games with a swing voter's curse for some preference and information configurations. They extend the experiments of Battaglini and others by exploring an environment where poorly informed voters are not completely uninformed—they just receive lower-quality informative signals. This can lead to multiple symmetric pure strategy equilibria. There can be an equilibrium where all voters vote and, at the same time, an equilibrium where the poorly informed voters abstain.[118] If the information gap is large between high- and low-quality signals, then the latter equilibrium is more efficient, while the full-turnout equilibrium is more efficient when the information gap is small. They find significant abstention in both cases, suggesting that efficiency is not a good selection criteria in these games and also suggesting that the logic of equilibrium abstention in these asymmetric information games is intuitive and compelling even for naive subjects.

A natural question arises concerning the relation between these results for the swing voter's curse summarized before and experimental findings about the well-known winner's curse problem that leads to overbidding in common value auctions. Like the winner's curse in auctions, the swing voter's curse can happen only if there is some degree of common preferences shared among some subset of voters (bidders) and if voters do not condition expected payoffs properly on the strategies of other players *and* low-probability hypothetical events. In the case of the common value auction, the hypothetical event is winning the auction, which is not known until after the bid is submitted. In the case of the swing voter's curse, the hypothetical event is casting a decisive vote, which is not known until all votes have been counted and a candidate has been elected. Rational decision making in both cases requires a deep understanding of the strategic complexity of the game as well as a correct (and subtle) application of Bayes' rule. In spite of this apparent similarity between the environments, the results reported from laboratory experiments are quite different. In the case of the swing voter's curse, the findings are relatively consistent with the theoretical equilibrium: voters seem to "get it" and abstain (or balance against partisans) when they are poorly informed. In contrast, bidders in laboratory auctions often fail to adequately discount their bids to compensate for the winner's curse effect. This is puzzling: Why is the winner's curse in laboratory auctions a major behavioral effect that persists with experience, while the swing voter's curse in elections appears to be at best a minor behavioral phenomenon that declines rapidly with experience? There are several possible answers.

One conjecture has to do with learning and feedback. In the swing voter's curse experiments, voters observe that many voters are abstaining in early rounds, so imitation could lead to convergence in the case of no partisans. Also, in the swing voter's curse, experiments where the informed voters are *perfectly informed*, an uninformed voter who was pivotal and voted for the wrong candidate probably can infer that the voters who voted the other way were probably perfectly informed. In fact, these perfectly informed

TABLE 6.6:
Observed frequency of uninformed bids.

			All 30 Rounds				Last 15 Rounds			
Session	*Treatment*	*Bid*	14	B^{CE}	1^{BNE}	*n*	14	B^{CE}	1^{BNE}	*n*
1	B = 10		0.04	0.07	0.89	240	0.03	0.01	0.96	120
2	B = 11		0.04	0.03	0.93	240	0.03	0.01	0.95	120
3	B = 11		0.04	0.07	0.89	240	0.04	0.00	0.96	120
Pooled			0.04	0.06	0.90	720	0.04	0.01	0.95	360

voters conform to equilibrium by voting their signal virtually 100% of the time. If uninformed voters make this reasonable inference, then it is an easy next step to adapt their behavior and abstain.

A second conjecture is that both the information structure and the strategy space in a typical common-value auction experiment are far more complex than in the swing voter's curse experiments. In the auctions, the signals are virtually continuous and the joint distribution of signals and states very complicated. The strategy space is also nearly continuous. In the swing voter's curse experiments, the strategy space is discrete, with only three possible actions, the state space and signal space are both binary, and the signals (in most cases) are perfectly informative. With this second conjecture in mind, the following experiment was designed and a few sessions conducted.

The idea is to run a common-value auction experiment where the informational and strategic environments are as close as possible to the laboratory elections. In the elections reported in Battaglini, Morton, and Palfrey (BMP; 2008b, 2010), there are two states of the world, perfectly informative signals, and three possible choices. We study here a first-price common-value auction environment with nearly the same information structure: there are two states (a high common value and a low common value), perfectly informative signals, and three possible choices (bid high, bid low, bid medium).

The experiment, reported in Palfrey (2012), is a seven-bidder first-price common-value auction. There are two possible common values, high ($V = \$20$) and low ($V = \$4$). It is common knowledge that these are the only two possible values, and they are equally likely. Before the auction begins, the true value is drawn by nature, and exactly three of the bidders are informed of the true value. The remaining four bidders receive receive an uninformative signal.[119] The bidders then are allowed to submit one of three bids, \$14, \$$B$, or \$1. There were two slightly different treatments. In one treatment, $B = \$10$. In the second treatment, $B = \$11$. Initially, one session of each treatment was conducted, using Caltech students as subjects, and later a second session with $B = \$11$ was conducted to see if the results were replicated. Each session had fourteen subjects, and each subject was in thirty seven-bidder auctions, with a random matching protocol (and random assignment of informedness). The equilibrium in all cases is for informed bidders to bid \$14 or \$1 if the value is \$20 or \$4, respectively. Uninformed bidders should always bid \$1. Uninformed bidders bidding \$$B$ is a cursed equilibrium strategy.

Out of 540 bids by informed bidders, 539 were equilibrium bids. More surprising is that uninformed bidders quickly converged to the strategy of bidding \$1. This is summarized in Table 6.6.

The findings, while based on a small sample, are decisive. There is very little winner's curse behavior in these auctions, and it completely disappears with experience. There is almost no difference between the two B treatments nor across the three sessions. If anything, there is less winner's curse behavior in these auctions than there is swing voter's curse behavior in the BMP elections. These results suggest that it would be useful to explore more-complex information environments in the committee setting in order to dig more deeply into the swing voter's curse phenomenon. If the conjecture in this paper about the connections between complexity and cursedness is valid, then it should not be too difficult to design a swing voter's curse experiment where cursed behavior is prevalent. On the theoretical side, it would seem useful to explore and develop models that connect some formal measures of complexity or transparency of games to the degree to which economic and political agents are subject to behavioral limitations such as cursedness, strategic unsophistication, and noisy best response.

Principal Findings for the Swing Voter's Curse

1. Voters with relatively poor information abstain in ways that are largely consistent with swing voter's curse theory. That is, for the most part voters avoid the curse by abstaining.
2. There is some cursed voting behavior (10%–20%) if the uninformed voters' prior on the state of the world is biased for one of the states.
3. Uninformed voters *balance*, with a significant fraction of them voting against the partisan side in the election. This fraction increases in the number of partisans.
4. The results scale up to larger electorates.

6 VOTING MECHANISMS THAT REFLECT PREFERENCE INTENSITY

Most of the classic literature in voting theory and social choice theory employs ordinal models of preference in one dimension or with a finite number of alternatives or consider purely redistributive politics, as in the BF model. Spatial models typically assume Euclidean preferences, which, in two dimensions, implies that there is no difference in preference intensities across issues.[120] This lack of emphasis on preference intensity, or "willingness to pay," stands in stark contrast to the classic literature on public goods, where intensities of preference for a public good play a fundamental role; in the standard public goods literature intensities are often captured by marginal rates of substitution between public goods and a numeraire private good.

In the absence of different preference intensities across issues, there are some compelling arguments for using majority-rule issue-by-issue voting. In particular, majority rule is the unique method for choosing over binary issues in a way that simultaneously respects anonymity of the voters, is neutral with respect to the alternatives being voted on, and is positively responsive to preferences. However, with differing preference intensities across issues (as represented by different marginal rates of substitution between the public decisions and a numeraire private good, or "private valuations" as in auction theory), it is easy to find examples where majority rule will lead to highly inefficient public decisions.

A typical example of inefficiency might have three voters and two binary issues. In issue one, the alternatives are $\{x_1, y_1\}$, and in issue two the alternatives are $\{x_2, y_2\}$. Suppose the private valuations of voters are as in Table 6.7.

The majority-rule outcomes are y_1 for issue 1 and y_2 for issue 2. However, the efficient outcome would have outcome x_1 for issue 1 and x_2 for issue 2. Majority-rule issue-by-issue voting clearly fails to lead to an efficient decision. Are there better voting

TABLE 6.7:
Voter preferences on two binary issues.

	x_1	y_1	x_2	y_2
Voter 1	15	0	5	0
Voter 2	0	8	0	2
Voter 3	0	4	0	2

methods that circumvent this problem of the "tyranny of the majority"?[121] One might propose to allow for vote trading, but voters 2 and 3 always win on both issues, so there are no mutual gains from vote trading. One might also propose to offer an "omnibus" bill that combines the two issues. For example, one could vote for the efficient combined outcome x_1x_2 against the complementary alternative y_1y_2. But this doesn't work because voters 2 and 3 both prefer y_1y_2 to x_1x_2, which would actually result in the *least efficient* outcome on both issues. In fact, the issue by issue majority rule outcome, y_1y_2 is a Condorcet winner, or majority-rule core, and hence a very stable outcome with respect to simple majoritarian mechanisms.

The rest of this section reviews the experimental findings based on various theoretical voting mechanisms that have been proposed to ameliorate the preference-intensity problem inherent in majority rule (or any other simple voting rule based solely on ordinal preferences). The basic approach is along the lines of mechanism design theory, and hence the main questions—and the questions most intently focused on in the laboratory experiments—concern the welfare gains of these alternative voting mechanisms as compared to simple issue-by-issue majority rule. Under what conditions does an alternative voting scheme lead to better or worse outcomes than majority rule, from a utilitarian criterion? Is the kind of strategic behavior predicted by equilibrium theories of behavior in these voting games similar to what is observed in the experiments? Do some of these alternative schemes perform better than others? Are the findings robust with respect to environments and institutional details?

6.1 *Mechanisms Where a Budget of Votes Can Be Allocated Across Issues*

Storable Votes A mechanism called storable votes was proposed by Casella (2005, 2011). A committee of voters faces an upcoming sequence of votes on T binary issues. In the simplest version of it, each voter is endowed with a total of T votes, one for each issue, but a voter can choose to abstain on issue t and save the vote for use in a later issue. Thus, for example, in the case of $T = 2$ a voter can cast one or zero votes on issue 1, and as a result have one or two votes for issue 2. One solves for subgame perfect equilibria in stage-undominated strategies (i.e., any votes cast on an issue are cast for the voter's preferred alternative).

Referring to the preceding example, there is an equilibrium where voter 1 votes twice on issue 1 and voters 2 and 3 each mix between voting twice on issue 1 and voting once on each issue. Even though the outcome is not fully efficient—a probability distribution over outcomes—it improves over issue-by-issue majority rule.[122] The main theoretical result is that storable votes typically improves over simple majority voting.

Casella, Gelman, and Palfrey (2006) study a variation[123] of this voting mechanism using a laboratory experiment for $T = 2, 3$ and committee sizes $n = 2, 3, 6$. Each session consisted of between 8 and 21 subjects playing 30 repetitions of the storable votes mechanism using a random matching protocol. Valuations for each voter's favored outcome on an issue were independently and uniformly distributed between 1 and 100. The direction of preference of each voter (i.e., which outcome on an issue was a voter's favored outcome) was determined by a computerized coin toss. This was explained carefully to the voters. At the beginning of period t each voter was privately informed of his or her own valuation and direction of preference for issue t but were not yet informed of a valuation or directional preference for future periods. Each voter's endowment of bonus votes was fixed at $B = T$. There were several findings. The main finding was that the efficiency improvements predicted by the theory were largely borne out in the data. A second finding was that the voting strategies of subjects were substantially (and significantly) different from the equilibrium strategies. For example, in the case $T = 2$, equilibrium strategies always have voters using *all* their bonus votes on one single issue rather than splitting. However, splitting of bonus votes was commonly observed. On the other hand, subjects did generally use monotone strategies, in the sense that the number of bonus votes used on the first issue was an increasing function of the voter's valuation on that issue. The paper considers a range of stochastic choice models and shows that among these models, the logit QRE model organizes the data rather well.

Casella (2011a) investigates a variation of the model where an agenda setter can choose the order that issues are voted on. There exist equilibria where the agenda setter indeed has proposer power in the sense of getting a higher expected payoff than if the agenda were set randomly. For the example with $T = 2$, this is done by first conducting a vote on the issue for which the setter has the higher valuation. This signals to the other voters that the agenda setter is going to use his or her bonus votes for the first issue, which has a preemptive effect on other voters. Theoretically there are still overall welfare gains compared to simple issue-by-issue majority voting. The experiments (using $n = 3, 4$ and $T = 3$ and a random matching protocol) confirm the welfare gains, thus replicating the findings of Casella, Gelman, and Palfrey (2006) in a more complex setting. However, there is no measurable proposer advantage. The setter is unsuccessful in exploiting his control of the agenda order.

One of the supposed advantages of storable votes, besides producing some efficiency gains, is overcoming the problem of the tyranny of the majority. This has been a topic of considerable importance in democratic theory, since the legitimacy of majority rule democratic procedures may be eroded away if minority political factions always fail to have an effective voice, even on issues where their preferences are more intense than the majority. Storable votes make it feasible for minority factions to exercise power on at least some issues by concentrating their votes on those issues most important to them.[124] Casella, Palfrey, and Riezman (2008) investigate the question of whether minorities are more successful with a storable votes system than simple majority rule and how this can affect efficiency. Their experiment is another variation on Casella, Gelman, and Palfrey (2006), having different numbers of members with preferences for or against proposals. To reflect the importance of *systematic* minorities, the smaller faction was always in favor of outcome a_t and the larger faction was always in favor of outcome b_t. Thus, under simple majority rule, the outcome would *always* be b_t for all t. The experiment varied a number of factors, such as the correlation of valuations and the ability of groups to communicate prior to voting. The main finding is that storable votes does indeed help minorities win on those issues where they have the highest valuation. This effect is magnified when their valuations are correlated. The second finding is that this increase in minority representation comes at essentially no efficiency loss. The third finding is that the ability coordinate via direct communication had relatively little effect on outcomes.

Qualitative Voting and Linking Decisions The storable votes mechanism is but one example of a more general phenomenon that Jackson and Sonnenschein (2007) refer to as *linking decisions*. That is, one can link the outcomes across issues in such a way that voters who are successful on one issue will be less likely to be successful on other issues. Such mechanisms create incentives for voters to adopt strategies that will be more likely to lead to successful outcomes on those issues they care most about. In the storable votes mechanism, this is completely intuitive: by using up one's bonus votes on issue 1, it reduces the likelihood of winning on issue 2. Jackson and Sonnenschein consider a more general class of mechanisms where voters can cast continuous votes (similar to bids) for or against each proposal, subject to a budget constraint on total votes. However, voters are effectively constrained so that the frequency distribution of votes they cast across the issues is tied to the probability distribution of their valuations. Thus, for example, if valuations were drawn from a uniform distribution, then a voter would have to cast votes across the issues that approximated a uniform distribution. Such a mechanism has strong incentive compatibility properties if there is a large number of issues and hence leads to efficient decisions in the limit as the number of issues becomes infinite.

Hortala-Vallve and Llorente-Saguer (2010) conduct an experiment to explore a mechanism that links a finite number, N, of issues in a committee of two members by endowing each member of the committee with a budget of six votes to allocate across the issues. Voting takes place simultaneously on all N issues, using majority vote with ties broken randomly.[125] They run treatments of $N = 2, 3, 6$. The two members have opposite preferences but can differ in their intensities (valuations) on each issue, as in the storable votes model. One is always in favor and one is always opposed in all issues. Intensities are independent draws from a uniform distribution over a coarse grid ranging from 7 to 11 possible values. Voting takes place after each member has observed his or her own intensities for all issues but none of the intensities of the other voters. Thus, it is essentially the same as the storable votes experiment, except all valuations are announced at the beginning and all voting takes place simultaneously. The unique Nash equilibrium predicts efficiency to be above 80% in all treatments and to be increasing in the number of issues. Both these equilibrium properties are observed in the data. However, as in the storable votes experiments, subjects generally do not use equilibrium strategies, although strategies are nearly always (96%) weakly monotone in valuations. That is, more votes are allocated to higher-intensity issues. As is the case with storable votes, the mechanism is somewhat robust in the sense that significant efficiency improvement results simply from the use of monotone strategies, even if they are not using equilibrium strategies.

Hortala-Vallve, Llorente-Saguer, and Nagel (2012) compare the performance of the preceding mechanism to open negotiation with unlimited communication and a deadline and investigate how the comparative performance depends on the information structure. Under negotiation, an agreement requires a vector of decisions, one for each issue.[126] Valuations are drawn uniformly from a grid of 10 valuations, {50, 100, 150, …, 500} subject to the constraint that valuations across all issues for a voter sum to 600. Thus there is dependence across issues in the draws for a given voter but independence across voters. In case the deadline is reached without agreement, both voters receive 300, the expected payment if there were to be a coin toss on each issue. In the voting mechanism, ties result in each voter receiving half their valuation.

As in the earlier experiment, they consider $N = 2, 3, 6$. They find an interesting interaction effect between information conditions and mechanism performance. With complete information the bargaining mechanism produces more efficiency gains, but the comparison is reversed with incomplete information.

Engelmann and Grimm (2012) also conduct an experiment using a simplified version of the linking mechanism. Subjects are assigned valuations (intensities) across forty issues and are paired ($N = 2$). The issues are decided in sequence. There is no repetition of the task. The two members of a pair have opposite directions of preference on a binary issues. Valuations can take on only two values, high or low, which are determined randomly and independently across issues. For each issue, subjects are asked to say whether their valuation is high or low. If they make different announcements, then the social decision is the one preferred by the agent with the high valuation. If they both make the same announcement, the social decision is determined by a coin flip. Finally—and this is the key—subjects are allowed to announce high valuations on only twenty of the forty issues.[127] It is an equilibrium in this game to announce truthfully unless one has high valuations on more than twenty issues (in which case it is an equilibrium to randomly select twenty of those issues to announce high). Theoretically, efficiency should be almost perfect, in contrast to simple majority rule, where there would be a tie in each period, so efficiency is 50%. They contrast this with a mechanism that is essentially equivalent to simple majority rule with a random tie break.

The findings track the theoretical predictions. In the (majority-rule) treatment with no constraint on high announcements, subjects announce high nearly all the time. In the mechanism that links decisions by constraining high announcements, subjects honestly report their intensities about 90% of the time.

Principal Findings for Mechanisms Where Voters Have Multiple Votes to Distribute Across Issues

1. Efficiency is generally higher than simple majority rule, as predicted.
2. Voting strategies are monotone: voters use more of their budget on high-valuation issues, but the response is smoother than predicted by theory.

6.2 *Vote Trading and Vote Markets*

At least since Buchanan and Tullock (1962), scholars in political science have conjectured that having a market for votes could potentially lead to more efficient decision making in committees, drawing an analogy with the first welfare theorem of general equilibrium theory. Two different models of a market for votes have been studied. The first model, usually called *vote trading*, or *logrolling*, is a model of pure exchange. The second model is in the Marshallian tradition, where votes are traded against a numeraire private good commodity, or money.

Vote Trading and Logrolling With logrolling, or vote trading, a committee member who feels strongly about issue 1 can trade his or her vote on issue 2 to another voter who feels strongly about issue 2. If these voters would otherwise be pivotal on these two issues, they have clear incentives to make such a trade. This is essentially what is mimicked in the storable votes mechanism, but the mechanisms are different, so equilibrium outcomes may be different. Riker and Brams (1973) develop a noncooperative game model of vote trading and show that in some cases vote trading can have negative efficiency consequences because of externalities. Indeed the two voters who trade their

TABLE 6.8:
Voter valuations for a nonexistence example.

Voter	*X*	*Y*
1	10	0
2	12	0
3	0	30

votes will obviously have made a mutually beneficial exchange in equilibrium, but this can impose costs on voters who were not involved in the trade. They construct examples illustrating how the external costs can easily outweigh the benefits to the vote traders.

McKelvey and Ordeshook (1980) conduct an experiment to see whether vote trading leads to higher or lower efficiency than the outcome that would arise under simple issue-by-issue majority rule without vote trading. They examine three-person and five-person committees and compare outcomes where binding bilateral commitments are possible to outcomes under more-open committee-bargaining protocols more along the lines of the unstructured committee-bargaining experiments described earlier in this survey.[128] With binding bilateral commitments, they find some support for the Riker-Brams hypothesis that permitting vote trading can lead to inefficient allocations. However, if agreements to trade votes are not binding and the committee of the whole has prevote discussions, then this kind of inefficient logrolling is just not possible. Since the latter allows for essentially costless coalition formation of more than two members, bilateral attempts to reach deals that are harmful to the group as a whole are undermined. As a result, cooperative game-theoretic solution concepts organize the data from the open-bargaining experiments without binding vote-trades much better than the noncooperative vote-trading model.

Markets for Votes A market for votes can lead to more efficient outcomes, even in the case where there is only one binary issue. In particular, if the minority coalition in favor of a proposal has more intense preferences than the majority coalition that opposes the proposal, then members of the minority would be willing to pay members of the majority to vote for the proposal in such a way that all members of the committee are better off. One possible way to achieve this is to allow members of the committee to openly trade their votes for money. The idea obviously extends to multiple issues as well, and the natural model to apply is general competitive equilibrium, where money is modeled as a numeraire perfectly divisible private good commodity and utility is additive across issue valuations and money.

The difficulty with this approach is that the market for votes is somewhat pathological, for a variety of technical reasons. It is a market with complications, including externalities, indivisibilities, and public goods, and the outcomes respond to vote allocations in discontinuous ways. Furthermore, votes have no intrinsic value at all and have only indirect value if a voter is pivotal. As a result, competitive equilibrium as one usually defines it fails to exist.

The nonexistence problem is illustrated by the following simple example from Casella, Llorente-Saguer, and Palfrey (2012). Suppose a committee deciding on a binary decision (X or Y) under majority rule has three voters, 1, 2, and 3. Voter valuations are given in Table 6.8.

The majority rule outcome without a market for votes is X, but the efficient decision is Y. What would a competitive equilibrium look like? It would be a price p and demands

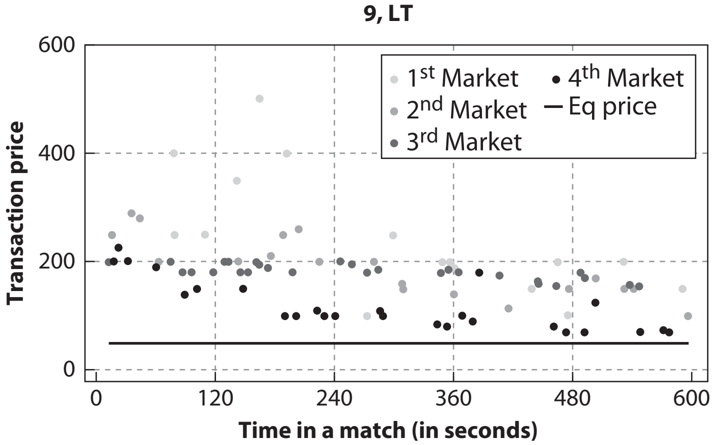

Figure 6.15: Price dynamics in a market for votes. *Source*: Casella et al. (2012).

(x_1, x_2, x_3) such that x_i is an integer greater than or equal to -1 and demands sum to zero. At any positive price, voter 3 demands at most one vote: Any positive price supporting a vote allocation where either side has more than two votes cannot be an equilibrium; one vote would be redundant and so at any positive price there would be excess supply. Voter 3 could buy 1's vote at a price of 11. But again the market will not clear: Voter 2's vote is now worth nothing and therefore 2 would be willing to sell it for 11. In fact, any positive price supporting 3's purchase of one vote cannot be an equilibrium: the losing vote is worthless and would put up for sale at any positive price. But a price of zero cannot be an equilibrium either: at zero price, 3 always demands a vote, but 1 and 2 will not sell and there is excess demand. Finally, any positive price supporting no trade cannot be an equilibrium: if the price is at least as high as 3's high valuation, both 1 and 2 prefer to sell, and again there is excess supply; if the price is lower than 3's valuation, 3 prefers to buy and there is excess demand.

Casella, Llorente-Saguer, and Palfrey (2012) define an ex ante competitive equilibrium for a market for votes like this one and show by construction that a nontrivial equilibrium exists. The equilibrium *always* results in dictatorship if there is any trade at all. Consequently, the market for votes generates welfare losses, relative to simple majority voting, if the committee is large enough or the distribution of values are not highly skewed. They test the theoretical implications by implementing a competitive vote market in the laboratory using a continuous open-book multi-unit double auction.

The experiment uses committees of sizes 5 and 9, and each committee engages in competitive markets for votes under four different distributions of valuations. Following standard laboratory market protocol, each schedule of valuations is repeated independently for multiple repetitions to allow for price discovery and convergence. A total of twenty markets were conducted for each session (five repetitions of each of the four valuation schedules). They have three main findings.

The first finding is that prices begin above the competitive equilibrium and decline over time to a level above the risk neutral competitive equilibrium price but close to or within the range of competitive equilibrium with risk-averse voters. Estimates of asymptotic price convergence fail to reject the competitive pricing model in six out of eight treatments and reject it marginally in the remaining two treatments. Figure 6.15

shows the price dynamics for one of the valuation schedules in four different sessions. The equilibrium price under risk neutrality for the markets in the figure is 50, and the equilibrium range with risk aversion is 50–100. The prices labeled as Market 1 consist of completely inexperienced traders, while Market 4 traders had the most experience.

Second, in smaller committees, dictatorship resulted between 80% and 100% of the time when traders were experienced. In larger committees, where the purchase of four votes is required for dictatorship, the frequency of dictatorship was significantly lower but increased with experience.

Third, the welfare predictions of the theory were borne out in the data. The difference in efficiency between vote markets compared to majority rule without vote trading had the correct sign for all treatments.

Casella, Palfrey, and Turban (CPT; 2014) investigate several related questions about markets for votes but with some important differences in both the approach and the motivation. First, the informational conditions are different; in Casella, Llorente-Saguer, and Palfrey the direction of preference (i.e., whether a committee member would vote for X or Y) was private information, and the direction of preference was independently drawn with equal probability for each member. In CPT, each member's direction of preference was common knowledge. The valuations were drawn independently from a uniform distribution, and this distribution was also common knowledge.[129] Second, the vote markets in CPT were implemented as one-sided continuous open-book auctions, where only bids to buy could be submitted; in Casella, Llorente-Saguer, and Palfrey (2012) markets were implemented as double-sided continuous open-book auctions where both bids and offers could be submitted. Third, CPT was motivated by questions about how vote markets affect the tradeoff between minority voice (i.e., the probability that an intense minority can win) and efficiency (as in Casella 2011b), and the extent to which this tradeoff depended on the ability of the members of each side to coordinate their actions. Coordination was modeled as a two-player game between party leaders, which reduces the problem theoretically to a bargaining game similar to Myerson and Satterthwaite (1983) or Cramton, Gibbons, and Klemperer (1987). The theoretical Bayesian equilibrium was derived for these games. For the multiplayer vote markets without coordination through party leaders, the ex ante competitive equilibrium solution was the benchmark used for predictions about behavior in the experiment.

The theory has strong predictions. In both cases (with or without coordination), trading falls short of full efficiency, but for opposite reasons: With coordination through party leaders, the minority wins too rarely; with a decentralized market in the absences of party leaders to coordinate trades, the minority wins too often. As a result, with party leaders, vote trading improves over no trade; with market trades, vote trading can be welfare reducing. These basic properties are satisfied by all experimental sessions. As in Casella, Llorente-Saguer, and Palfrey (2012), the data show some evidence of overpricing relative to equilibrium prices.

Principal Findings for Majority-rule Committees with Vote Markets

1. Transaction prices for votes are generally higher than the risk neutral competitive equilibrium price but converge downward to a range consistent with equilibrium pricing with risk-averse voters.
2. Dictatorship outcomes are observed more than half the time, and such outcomes increased with experience and decreased with committee size.

3. Decentralized markets for votes, or vote trading, can cause significant efficiency losses in a way that is consistent with the equilibrium model. Inefficiencies are greater in larger committees and in committees where the distribution of values is skewed toward higher values.
4. If vote trading is coordinated through party leaders, it generally leads to efficiency gains compared to no vote trading but falls short of full ex post efficiency.

7 WHERE DO WE GO FROM HERE?

The basic findings from these various classes of political science experiments are summarized at the end of each section. Therefore, rather than resummarizing, this section will provide some discussion that points to some possible promising lines of new research in each of these areas and a discussion of open theoretical questions and what sort of experiments might be especially informative.

What is on the horizon in the coming decade of laboratory research in political economy? First, one rather obvious observation. Using history as a guide, laboratory experiments in political economy will follow the current trends in theory. Thus, for example, new experiments relating to the design of optimal voting procedures in committees are a good bet, since there has been a flurry of theoretical research on this recently. In fact, we are beginning to see some experiments along this line, such as Hortala-Vallve and Llorente-Saguer (2010), Casella, Gelman, and Palfrey (2006) and Casella, Palfrey, and Riezman (2008), which explore the behavior of laboratory committees using novel voting methods that allow members to express strength of preference. The research on deliberation and information transmission in committees with conflicting preferences (e.g., Austen-Smith and Feddersen 2005; Meirowitz 2004) suggest a wave of experiments that would be a hybrid of the early committee experiments and the more recent experiments on information aggregation in juries. Dickson, Hafer, and Landa (2008) is an example of recent work along these lines. Questions of information aggregation in elections with more than two candidates is another promising area of research that is just starting to be investigated, both theoretically and in the laboratory (Bouton, Castanheira, and Llorente-Saguer 2012). A fourth set of experiments is suggested by theoretical models of endogenous candidate entry. These could blend insights from the earlier experiments on candidate spatial competition and more recent experiments on entry and coordination in abstract games. To date there have been only two experiments[130] that investigate citizen-candidate models of political competition and none that explore other models of competition where entry and candidate policy preferences are important factors. Such experiments are surely on the horizon.

A second, less-obvious observation is that the line between political science theory-testing experiments and experiments in economics and game theory has become very blurred. Accordingly, many of the recent developments and exciting frontiers in laboratory experiments in economics similarly represent exciting new frontiers of research in political science experimentation. The influence of behavioral models in economics that relax the classical model of perfect rationality has been felt in the political science community as well.[131] Similarly, the questions in which political scientists are interested and basic game-theoretic models overlap significantly with the kinds of questions and models explored by economists in the laboratory. The last example (competitive markets for votes) is one obvious example. But more to the point, political scientists are deeply interested in theories of free riding (e.g., Olson 1965;

Ostrom 1990), cooperation in repeated games (Axelrod 1984), coordination problems (Banks and Calvert 1992), contests and all pay auctions (Tullock 1980) and other such problems that are at the heart of pure and applied game theory. Thus, what many social scientists, or at least economists, automatically think of as "economics experiments" (just look at the title of this volume)—voluntary contribution to public goods, bargaining games, coordination games, repeated games, reciprocity in trust games, the dictator game, and so forth—address central questions in theoretical political science that are of significant interest to political scientists in all three main substantive fields of the discipline: American politics, comparative politics, and international relations.

This brings us full circle to the dilemma faced at the start of this essay: how to define political economy experiments? This essay limited the scope of that broad swath of research out of necessity. Political scientists should be and will be interested in many of the other chapters of this handbook. While some of the most exciting experimental research in political economy focuses, like this chapter, on voting, committees, and elections, the body of laboratory research in game theory and choice behavior that shares the interest of modern political scientists and economists alike resides in an important and even larger wing of the library of political economy experimentation.

ACKNOWLEDGMENTS

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NOTES

1. http://en.wikipedia.org/wiki/Political_economy. November 18, 2013.
2. See Alt and Shepsle (1990). It is also the title of a monograph series published by Routledge.
3. http://www.cambridge.org/us/catalogue/print.asp?isbn=9780521572156&print=y.
4. This includes work by the recent Nobel prize winning political scientist Eleanor Ostrom.
5. An exception is the chapter in the previous edition, concerning individual choice experiments (Camerer 1995).
6. This may be changing somewhat in laboratory experiments, as experimenters attempt to scale up the minieconomies and minipolities being studied.
7. A fourth feature of experiments in the economics tradition is the absence of deception, which is also generally the case in incentivized political science experiments.
8. See, for example, Plott and Smith (1978).
9. The most recent edition of *Robert's Rules of Order* (Roberts, Honemann, and Balch 2011) rambles on for more than 800 dense pages. *Robert's Rules for Dummies* (Jennings 2004) is 360 pages long.
10. Many of these solution concepts came from cooperative game theory—for example, the bargaining set and the von Neumann Morgenstern solution.
11. In the actual experiments, the outcome space is given by a finite grid of points on the plane.

12. There also some some secondary treatment variations regarding payoff magnitudes and communication limitations.
13. There are two *C* points because it depends on the order.
14. The quadrilateral in the series 3 figure indicates the min-max set for that preference configuration. These points can be defeated only by a minimum winning coalition of three voters. All other points can be defeated by even larger coalitions.
15. In series 1 committees, only seven out of forty committee outcomes were exactly at the core point. The frequency of core outcomes did not depend on the secondary treatment variables explored in Series 1: communication and payoff magnitude. However, the variance of outcomes was much lower in the high-payoff commitees.
16. Fiorina and Plott (1978) and later studies suggest alternative hypotheses that are suggestive of a behavioral model (such as fairness).
17. In spite of the earlier publication date, the experiments reported in Berl et al. (1976) were motivated by an early version of Fiorina and Plott (1978).
18. With issue-by-issue voting, a new alternative can alter the status quo on only one dimension.
19. Plott (1991) replicates the FP results for committees with between twenty-three and forty-five members.
20. McKelvey and Ordeshook (1981) also find evidence that core selection can depends on other details of the preference profile.
21. The voting agenda procedure in their voting experiment was constrained to a specific, well-defined multistage game, in contrast to the less-structured committee protocols used in most other experiments in this section.
22. Ordeshook and Winer (1980) conduct experiments with weighted voting and find results that are broadly supportive of the competitive solution.
23. Some related findings are reported in Miller and Oppenheimer (1982).
24. A number of subsequent studies have shown further evidence for the cardinality principle. For example, Herzberg and Wilson (1991) find that agenda access costs affect both the outcomes and the *agenda path* to these outcomes in majority rule committees with spatial preferences, both with and without a core. See also Eavey (1991) and Grelak and Koford (1997).
25. A more recent reexamination of these older committee experiments shows that *the uncovered set*, which is purely ordinal, organizes the data quite well across a broad set of experiments, in the sense that a large percentage of observations are contained in the uncovered set (Bianco et al. 2006). However, in many cases without a core, the uncovered set is a large subset of the Pareto optimal outcomes and, as such, makes rather nebulous predictions. For environments where a unique core outcome exists, the hit rate is quite small and is affected by order-preserving payoff transformations.
26. Obviously, this basic idea extends in a straightforward way to far more general environments, for example, discrete or multidimensional issue spaces, voting rules other than majority rule, and multistage political process (e.g., veto players, bicameral voting bodies, and so forth). Many such institutional features can be brought into the model under the general framework of structure induced equilibrium, an important insight and concept introduced by Shepsle and Weingast (1981). One can view the Romer-Rosenthal model as an early example of structure induced equilibrium.
27. Like the ultimatum game, since there are a discrete number of alternatives, there is also an equilibrium where the median voter receives a minimum positive surplus relative to the status quo.
28. This latter finding is similar to results reported in Isaac and Plott (1978) on the effect of a closed rule (i.e. only one proposal).
29. The closest to this are the multilateral bargaining experiments with voting, discussed later.
30. The author attributes this partially to his design, which allowed for repeated game effects. Still, he finds the main comparative static effect for his design, with more extreme setters proposing more extreme policies.
31. Farquharson (1969) was the first to study general properties of sophisticated voting over fixed agendas. Voters are assumed to have complete information about the preference orderings of all the voters. With incomplete information, the equilibrium analysis is much different (Ordeshook and Palfrey 1988).
32. A Condorcet loser is an alternative that is defeated in a pairwise vote with any of the other alternatives.
33. This was in part due to the presence of incomplete information in these experiments.
34. The authors also identify another deviation from their model predictions. Their model tends to underpredict the margin of victory.
35. After the decision, the authors sent out a questionnaire to get more-complete preference information from the members.
36. The target outcome coincided with the ideal point of the authors, as explained in the article.

37. Specifically, the agendas are all binary amendment voting procedures, subjects are given the ordinal preferences of the computerized voters, and they are told that the computerized voter will vote sincerely at every stage.
38. Subjects are allowed extensive practice in an unpaid agenda game, which they can repeat as many times as they wish. On average, each subject practices the task approximately five times, and they find no correlation between the number of practices by a subject and their tendency to vote sophisticatedly.
39. See Roth (1995) for a discussion of several of these studies.
40. See, for example, the centipede game study by McKelvey and Palfrey (1992) and subsequent studies of that game. Morton (2007) has an insightful discussion about why the centipede game is important for political science, particularly as it relates to legislative bargaining.
41. The findings about convergence and learning are mixed. See, for example, Nagel and Tang (1998). Ponti's (2000) theoretical adaptive learning model that generates cyclic dynamics in centipede games offers one possible explanation for these mixed findings.
42. Learning through repetition is also facilitated by their design, where the distribution of preference orders was fixed for all ten rounds; only the assignments of preferences changed.
43. The likelihood voters vote sophisticatedly is also higher in the pubic information treatment than the private information treatment, but significance (11%) fails conventional tests.
44. There are some extensions of this where the setter can have a second shot if the first proposal fails.
45. This does not reduce to exactly the equilibrium of the Rubinstein bargaining game if $n = 2$ and the voting rule is strict majority rule. The difference is due to the fact that in the standard Rubinstein game, the proposers alternate rather than being chosen at random.
46. This finding is similar to the phenomenon of incomplete rent extraction in bargaining games with side payments and in the Eavey-Miller experiment.
47. Rietz (1993) studies the use of the risk-neutralizing lottery procedure in the context of first-price auctions. See also Cox and Oaxaca (1995) and Walker et al. (1990).
48. The experiments reported in Diermeier and Morton (2005) were conducted around the same time, perhaps slightly earlier. They employed a different design and explored somewhat different questions. See the following.
49. In each session, subjects repeated the task fifteen times. There were exactly five subjects in each session, so these were "repeated-repeated games." To mitigate supergame effects, subject ID numbers were relabeled after each election was finished (i.e., a proposal passed). Subjects received payment for a randomly selected four out of the fifteen elections. Sessions were conducted manually using a blackboard and pencil and paper, rather than computers.
50. In the baseline treatment, Gamson's law predicts an equal split between the two coalition members.
51. Fréchette, Kagel, and Morelli (2005b) also run a DB treatment and report similar findings.
52. These delay rates were higher than was observed in the three-voter BF bargaining games reported in Fréchette, Kagel, and Morelli (2005a) and lower than the three-person DB committees with no discounting in Fréchette et al. Experience also significantly reduced delay in the three-voter games.
53. These experiments had no discounting built into the payoffs, so there is no *direct* efficiency loss from delay. However, if subjects' time is valuable, then these delays did create inefficiencies.
54. Unfortunately, for the allocation data analysis, a large chunk of the data is discarded because only passed allocations with minimum winning coalitions are considered.
55. Their main finding is very high rejection rates in early rounds, compared to infinite horizon bargaining experiments.
56. See also Hsu, Yang, and Yang (2008). They are particularly close to the experimental studies of n-person ultimatum games. See, for example, Guth and Van Damme (1998), Bolton and Ockenfels (2000), Knez and Camerer (1995), and Kagel and Wolfe (2001).
57. In most sessions, the task was repeated with random matching for twelve repetitions to allow for learning.
58. Quantal response equilibrium relaxes the best response assumption of Nash equilibrium with noisy best response but retains the assumption of rational expectations. See McKelvey and Palfrey (1995, 1998) and Goeree, Holt, and Palfrey (2005). It will be discussed in more detail in Section 4.
59. Christensen (2010) extends the design of this experiment by allowing for heterogeneity of public good preferences.
60. In the experiment, the "dollar" was divisible into sixty pieces. If anything, the grid used in the laboratory version was finer than necessary: over 90% of proposals were for allocations that were divisible by five.
61. The Markov perfect equilibrium pins down predictions in these games. The entire set of subgame perfect equilibria is, of course, much larger, following folk theorem types of arguments. In fact, the efficient path can even be supported in a subgame perfect equilibrium for large-enough discount factors, including the parameters used in the experiments. The formal argument is in Battaglini, Nunnari, and Palfrey (2012).

62. The efficient level of investment required investing 100% of the endowment in all of the first ten periods.
63. There were five voters in a two-dimensional space, with Euclidean preferences. Voter ideal points were the same as in some of their committee experiments.
64. McKelvey and Ordeshook (1982) also include results from a series of elections with similar procedures but where a Condorcet winner did not exist. In this case, there is no pure-strategy equilibrium. They find that the candidate locations converge to a central area in the Pareto set and conjecture that behavior is close to the mixed-strategy equilibrium of the game.
65. There were also some three-candidate elections, which are discussed later in this survey.
66. Voters also are assumed to know approximately where they stand relative to rest of the electorate on a left-right scale.
67. This is done by having the active candidate investing in effort before knowing his or her own quality level. This produces a signal equal to the sum of the effort choice and his or her realized quality level. The signal is then revealed to a subset of the voters. The motivation behind this signal structure is that the active candidate is an incumbent coming up for reelection, and the signal is some measure of his or her performance in office during his first term.
68. In a related study, Lupia (1994) investigates a different mechanism for information revelation in direct-legislation elections. His experiment demonstrates that when incompletely informed voters have information about the incentives of the author of ballot initiatives, they can use this information to increase the likelihood they cast the same votes they would have cast had they possessed perfect information about initiative.
69. See Key (1966) and Fiorina (1978).
70. The latter article also summarizes results from the experiments on contemporaneous information such as poll results or endorsements.
71. Of course, these experiments explore relatively simple environments and focus only on the main driving force of candidate competition. Future research will need to address the role of other factors such as voter turnout, campaign contributions, advertising, the role of parties and primaries, valence dimensions, and so forth.
72. For example the alternatives were labeled Orange (A), Green (B), and Blue (C) to avoid alphabetical order as a coordinating device.
73. An exception is Forsythe et al. (1996), where voting groups were reassigned only after every eight elections.
74. The BC rule requires voters to rank the candidates from most preferred to least preferred. The candidate with the highest average ranking wins. AV is similar to the plurality voting rule, except voters are permitted to vote for more than one candidate. The candidate with the most votes wins.
75. On the other hand, it seems harder to rationalize the contribution decisions of the type 3 voters.
76. The results were obtained much earlier than the publication date and presented at the 1977 Public Choice conference.
77. The intuition is twofold. All else equal, both candidates would like to locate near the center, because that's where the median voter is. However, the disadvantaged candidate can win only by distancing himself or herself away from the advantaged candidate, which leads to an incentive to move away from the median. Mixing occurs because the advantaged candidate can win by matching any pure strategy of the disadvantaged candidate.
78. The instructions used neutral terminology rather than presenting the task as a voting decision.
79. Despite the problems with multiple equilibria, the experiments provide an interesting source of data for understanding coordination failure and the dynamics of behavior in coordination games. Later, we also discuss the QRE analysis of these games by Goeree and Holt (2005), which provides a possible explanation for the early-round differences in W and PR turnout rates and the eventual decline and convergence of the two turnout rates.
80. We chose to not to break ties randomly because there were already several random variables in the design (the assignment of voting costs and the assignment to parties), and this was simpler. Instead, ties paid the expected value of a random tie break.
81. When $N = 3$, the toss-up and landslide treatments are the same.
82. The upset rate equals the probability the minority candidate wins.
83. The close election rate is the probability the election is either tied or one away from a tie. That is, the probability a voter is pivotal.
84. The competition effect is also supported in a recent experiment by Grosser and Schram (2010). They compare turnout in twelve voter elections where the larger party can consist of six, seven, eight, or nine voters.

85. The size effect is supported with the exception for the tossup races with twenty-seven versus fifty-one voters, where turnout was slightly more (less than half a percentage point) in the fifty-one-voter case than the twenty-seven-voter case.
86. The distribution of disturbances can be different from different individuals. See Rogers et al. (2009). With no restrictions on the distribution of disturbances, choice frequencies are not necessarily monotone and, in fact, can be anything. This is a general property of additive random utility models. See Haile, Hortascu, and Kosenok (2008) and Goeree, Holt, and Palfrey (2005).
87. The definition has been generalized to extensive form games (AQRE). Limit points of AQRE as $\lambda \to \infty$ are sequential equilibria.
88. In order to pool all treatments together, the horizontal axis represents the *normalized* voting cost, that is, the difference between the voting cost and the equilibrium indifference point (which varies across treatments).
89. Their analysis can be extended to studying quasi-symmetric equilibria in asymmetric participation games.
90. Cason and Mui (2005) independently proposed QRE as an explanation to some results they observe in participation games.
91. Theoretically, there is a parallel between QRE in complete information turnout games with homogeneous costs and Bayesian equilibria of the turnout games with privately known costs because the privately known costs can be interpreted as additive payoff disturbances.
92. Some recent papers have cast doubt on the reliability of elicited beliefs from subjects during the course of a decision or game theory experiment. See Palfrey and Wang (2009) and several of the papers they cite.
93. Voters were assigned to parties in the following way. First, three voters were assigned to each party. Then the remaining six voters were each assigned to one or the other party by independent coin tosses.
94. There is a large and growing literature in political science that uses field experiments and natural experiments to study various informational effects on voter turnout. See, for example, Gerber and Green (2000) and Lassen (2005).
95. Early voters can vote in the second stage if they abstain in the first stage.
96. Surprisingly, turnout rates are 50% higher for early voters than late voters in the no-information treatment, contrary to the symmetric equilibrium turnout rates. This huge asymmetry suggests that the labeling of early voters and late voters may allow groups to coordinate on asymmetric turnout equilibria.
97. In the positive-information treatments, the game is a signaling game, which introduces additional possible equilibria and may even enable subjects to coordinate on asymmetric equilibria. They also conduct a "partners" treatment, with 99 repetitions, so the data may reflect a mixture of asymmetric equilibria.
98. Observed turnout in that treatment is slightly under 50%.
99. Purely instrumental voters would have an incentive to vote their true preference since there is no direct cost to voting, regardless of the (positive) probability their vote is decisive.
100. In some variations, only yes voters are required to make a contribution if the vote exceeds the quorum.
101. This is not equivalent to eliciting the beliefs about pivot probabilities.
102. The question of causality is more complicated. These two tasks (voting and reporting beliefs) are not entirely independent. By voting yes, a voter increase the probability that the quota is achieved.
103. That is, the calculus of voting involves conditioning on the event that a voter is pivotal.
104. Ladha, Miller, and Oppenheimer (unpublished working paper, 1999) also investigate strategic voting in information aggregation experiments.
105. The analysis assumes retrial is not possible.
106. Under unanimity, the outcome was A unless all voters voted for B. Under majority rule, the outcome was A unless a clear majority voted for B.
107. In six-person majority-rule juries, α signal voters voted for A only 79% of the time. However, sincere voting is a weak equilibrium with an even number of voters because the rules required a *clear majority* for A to win. As a result, in equilibrium α signal voters are actually indifferent between voting for A and B.
108. Specifically, the study found that majority rule leads to more false convictions than unanimity in large juries and that larger unanimous juries produce fewer false convictions than smaller unanimous juries. Nash equilibrium predicts the opposite effect in both cases.
109. In Guarnaschelli et al. (2000), a student monitor determined the state of the world by rolling a fair die, and subjects drew their own signals from a virtual urn on their computer screen.
110. See Ali and Kartik (2012) and Callander (2002) for information aggregation models of bandwagon effects in voting games. Equilibrium bandwagon effects can occur in these games in a way that mimics choice behavior in the herding equilibrium of Bikhchandani, Hirshleifer, and Welch (1992).

111. Communication is essentially unrestricted and implemented by a chat box on each subject's computer screen. Messages can be either broadcast or targeted.
112. The exception is unanimity rule, which can achieve only a subset of the outcomes achievable by other voting rules.
113. The latter observation is a bit surprising, since the *group efficient* level of turnout coincides with the equilibrium level (100%) in the low-cost treatment.
114. All votes are sincere. A 0–0 tie after the first two stages is off the equilibrium path.
115. For example, in the low-cost treatment, the first voter abstains 33% of the time, and in the high-cost treatment, the third voter abstains more than 33% of the time following a 0–0 or 1–1 tie.
116. The expected effect of voting costs on both kinds of efficiency (higher costs lead to lower efficiency) were also observed.
117. Two of the $\pi = \frac{5}{9}$ session had only only seven subjects, so there was not rematching of committees between elections in those sessions.
118. In some of their treatments, there is also an inefficient third equilibrium, where low-information voters mix. In addition, there can be asymmetric equilibria. Because the sessions are run using a "partners" repeated-game design for sixty repetitions and committees are very small ($n = 3$), it is plausible that different groups converge to different asymmetric equilibria. The authors don't find evidence of these other kinds of equilibria in their data.
119. In the experiment, the uniformative signal was implemented as a statement on their computer screen that says, You are uninformed.
120. A few papers investigate more-general utility specifications in multiple dimensions, such as elliptical indifference curves, to allow for different intensities across issues.
121. There is a large literature on public goods mechanisms *using side payments* for producing efficient allocations, such as Groves mechanisms, the Groves-Ledyard mechanism, d'Aspremont and Gérard-Varet, and so forth. We are interested in problems where participants are endowed with voting rights. A few papers explore models that combine voting rights with side payments, and these are discussed in the section on vote markets.
122. The information structure in the standard storable votes model has incomplete information. In period t, voters know only their own valuation for the current issue but have only probabilistic information about other voters' current and future valuations and their own future valuations.
123. The main variation is that voters always have one regular vote that they must use in each issue but are endowed at the beginning with B bonus votes, that they may cast in addition to their their regular votes.
124. Other methods, such as supermajority requirements, also give minorities more power.
125. This is similar to the voting scheme proposed by Casella and Gelman (2008).
126. Failure to reach agreement results is a random coin toss on every issue.
127. Observe that this mechanism is equivalent to a storable votes mechanism, where each voter is given twenty bonus votes but is allowed to use at most one bonus vote on any given issue.
128. In the binding-commitment case, voters were given physical ballots for each issue, and there was a trading period during which the ballots could exchange hands, in a manner similar to trading baseball cards.
129. In Casella, Llorente-Saguer, and Palfrey, no distributional information was given about the distribution of valuations.
130. Cadigan (2005) and Elbittar and Gomberg (2009).
131. Indeed, if anything the political science community is even more open minded about such behavioral relaxations of rational choice theory. Traditionally, the modal behavioral view in political science has been quite hostile to and suspicious of rational choice theory. See for example Green and Shapiro (1994).

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