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VOTING ON ALLOCATION RULES IN A COMMONS WITHOUT FACE-TO-FACE COMMUNICATION: THEORETICAL ISSUES AND EXPERIMENTAL RESULTS

by

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I. Introduction

An immense outpouring of empirical studies has been published during the past decade focusing on the norms and rules that have evolved or been chosen to govern smaller, relatively homogeneous common-pool resources.[1] In many field settings, the tragedy of the commons has been avoided and robust institutions (Shepsle, 1989) have been used to govern fragile common-pool resources for several centuries (Netting, 1981; E. Ostrom, 1990). Empirical studies of existing field settings, while crucial for establishing external validity, are not immune to four threats to establishing a firm explanation of observed cooperative behavior. First, scholars can rarely obtain quantitative data about the potential benefits that could be achieved if participants cooperate at an optimal level or about the level of inefficiency yielded when they act independently. Second, it is thus difficult to determine how much improvement has been achieved as contrasted to the same setting without particular institutions in place. Third, without using expensive time series designs, studies only include those resources that have survived; and, the proportion of similar cases that did not survive is unknown.[2] Fourth, many variables differ from one case to the next. This means a large number of cases is required to gain statistical control of the relative importance of diverse variables. In this regard, the few studies that have attempted cross sectional control using a relatively large number of field cases have produced important results that complement individual case studies (see Tang, 1992; Schlager, 1990; Lam, 1994).

Laboratory experiments are an important antidote to these threats. The designer of an experiment knows exactly what the achievable optimum is for each experimental set of conditions, as well as the relative efficiency resulting from behavior in diverse institutional settings. In experiments that allow for explicit communication, groups that fail to achieve an agreement and continue to make independent and inefficient decisions are part of the data produced by an experimental program. Thus, the proportion of groups achieving a joint agreement under diverse conditions and the level of conformance to agreements are known. Finally, a major advantage of the experimental method is exactly that of controlling extraneous variables. In this regard, experimental settings are sparse in contrast to natural settings, but that is part of their advantage.

Experimental studies have generated data that is highly consistent with the information from smaller and more homogeneous field settings.[3] Individuals using common-pool resources who act independently tend to overharvest, congest, and/or destroy these resources. When given an opportunity to communicate on a face-to-face basis about the situation they are in, however, small symmetric groups routinely agree upon joint strategies and implement them consistently.[4] In repeated settings, individuals use communication as a mode of sanctioning others (E. Ostrom, Walker, and Gardner, 1992). When given an option to impose a sanctioning institution in a repeated setting, individuals who agree upon a joint strategy and on a sanctioning institution achieve close to 100% efficiency without having to use sanctioning very often (ibid.).

While the findings from experiments where no face-to-face communication is allowed are consistent with predictions from finitely repeated, non-cooperative game theory, the findings that "mere talk" can produce a self-enforcing agreement are not. New theoretical developments have, however, provided good explanations that are not just *ad hoc* fixes on existing theory. We have developed a positive theory of measured response. Individuals who adopt this heuristic for playing in repeated common-pool resource games can agree upon joint strategies and achieve high levels of efficiency without external enforcers, so long as no player egregiously breaks the agreement (E. Ostrom, Gardner, and Walker, 1994). Crawford and Ostrom (1995) have recently demonstrated that individual preferences that include internal weights for breaking promises create equilibrium regions where cooperation is sustained. Similarly, Güth and Kliemt (1995) have shown that having internal costs associated with breaking promises is also evolutionarily stable under similar conditions. Finally, Bester and Guth (1994) have developed a related model showing that concern for the payoffs that others receive (called "altruism" by Bester and Güth) are evolutionarily stable under specific conditions. In both cases, the identity and "type" of all players are known (or can be known at low cost) to other players before playing a round of a game. This kind of low-cost information about the trustworthiness and other-regardingness of participants can be achieved in the smaller, more homogeneous communities that have been studied in the field and in the lab.

The studies cited above are indicative of the progressive research program that has examined smaller common-pool resources being used by well-defined and relatively homogeneous participants. Starting with theoretical predictions that cooperation is unlikely in common-pool resource situations, field research produced contrary evidence. Carefully designed experiments produced evidence consistent with field studies. Research started on the simpler systems of interest where the incentives were highly salient and clear to the participants and observers and moved from these simpler systems to more complex settings. New theoretical advances—not *ad hoc* fixes—now provide explanations for these robust empirical findings. Contrary to the assertions of Green and Shapiro (1994), a research program based on rational choice theory has conducted extensive empirical research informed by and informing theoretical foundations. Many interesting questions remain. One of the more important concerns the impact of large exogenous changes on the adaptability of endogenous institutions and the stability of these micropolities over time.

The realm of larger common-pool resources, which frequently involve more heterogenous groups of users, appears now to be ripe for a similar, long-term, cumulative research program. Cases from the field are not so consistent nor positive when the focus is on larger resources and/or more heterogeneous sets of participants (Keohane and Ostrom, 1995). Ocean fisheries are notoriously difficult to regulate. Many commercial species have been exhausted or are severely threatened (Norse, 1993). Many countries have signed international agreements, such as the 1973 Convention on International Trade in Endangered Species of Flora and Fauna, the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, and the 1992 Convention on Biological Diversity. Unfortunately, the record of achieving conformance to international agreements related to global commons has not been as positive as the level of conformance with shared understandings about agreements in smaller, local commons (Choucri, 1993). Yet some larger and/or heterogeneous groups do agree upon joint strategies to avoid major environmental disasters (Haas, 1989; Haas, Keohane, and Levy, 1993).

In these settings, however, it is not possible for individuals to communicate with one another on a face-to-face basis, to use measured responses,[5] or to rely heavily on trust and reputation for keeping promises without relying on external enforcement. To govern such systems requires the self-conscious use of formal institutional mechanisms for selecting a variety of rules to be used over time. Essential rules address questions regarding who is included or excluded from access to a commons, how information will be generated about behavior and outcomes, and how benefits (and costs) will be allocated over time. Allocation rules are among the most crucial rules to be selected because they determine the distributional consequences and affect the overall efficiency of a system (see Cornes and Fulton, 1993; Lueck, 1994).

Voting is a commonly used formal institutional mechanism for determining rules to be used by larger collectivities of individuals. The diversity of voting systems, however, is as great as the diversity of market mechanisms (Levin and Nalebuff, 1995). One of the major findings from experimental studies of market mechanisms over the past two decades is the sensitivity of outcomes to changes in the market rules within identical environments (Davis and Holt, 1993). Experimental studies of voting also show that procedural rules can significantly impact outcomes (Plott and Levine, 1978; Fiorina and Plott, 1978; McKelvey, Ordeshook, and Winer, 1978; Hoffman and Plott, 1983; Wilson, 1986). In an effort to understand why governance arrangements have been developed and sustained in some larger common-pool resources, but not others, one needs to understand the relationship between the particular voting rules and the type of allocational rules adopted to structure a continuing operational-level situation.

The theoretical and empirical studies of voting have generally concentrated on voting arenas without connecting the collective choices that are adopted in such arenas to subsequent games that individuals play within the rules decided upon in the voting arena. By focusing on voting at a single level of analysis, theorists have made substantial breakthroughs concerning:

- the impossibility of guaranteeing that individual, ordinal, transitive preferences will be aggregated into collective, transitive preferences (Arrow, 1951, and the immense literature on social choice that followed his work);
- the possibility that those who control an agenda using simple majority aggregation rules can reach any policy outcome in a multidimensional space when individual, convex preferences lack a Condorcet winner (McKelvey, 1976, 1979); and
- the structure-induced stability achieved when procedural rules, such as germaneness, jurisdictional authority, and voting on the status-quo last are included in the analysis (Shepsle, 1979, 1986; Wilson, 1986).

In disconnecting voting games from the operational games they frequently structure, considerable clarity has been achieved in understanding collective-choice processes, but at the cost of understanding multilevel games where collective choices are closely linked to the structure of ongoing operational games. In this paper, we will focus on multilevel games to examine how the voting rule used at one level affects the structure of an ongoing commons dilemma game at an operational level.[6] In other words, we will formally analyze and empirically examine what allocational rules are selected to structure an operational game when the *same* participants vote on the allocation rule to be used in subsequent operational games. We are particularly interested in both efficiency and distributional consequences.

Focusing on the effect of particular voting rules (at one level) on the choice of allocation rules (to be used at a second level) allows us to examine the process and consequences of institutional change (Knight, 1992; North, 1990; Libecap, 1989). Many contract and spontaneous theories of institutional change have explicitly or implicitly assumed that new institutional rules are adopted when the collective benefits of new constraints on actors are larger than the collective benefits of the prior set of constraints. In other words, a change in the rules is viewed as a solution to collective-action problems. The process of institutional change is assumed to involve moving from less efficient to more efficient games. The impact on distribution is often ignored.

Viewing institutional change as inherently benign has been challenged by many scholars. Among scholars relying broadly on rational choice theories, Jack Knight has been among the most active. Knight views institutions as the *"product of the efforts of some to constrain the actions of others with whom they interact"* (Knight, 1992: 19). The main consequence of this shift in view is that the development of institutions over time is *"not best explained as a Pareto-superior response to collective goals or benefits but, rather, as a by-product of conflicts over distributional gains"* (ibid.). Knight's work heightens awareness of the importance of the distributional consequences of many rules and the consequent conflict that can be expected over the choice of specific rules. In his own analysis of institutional change, Knight focuses on bargaining models where unanimity is required for a change in rule and the important variable in predicting which rules will be selected are the status quo threat points of the participants. When participants have an unequal prior distribution of resources, one can expect new rules to be selected that favor those with greater resources.

In addition to examining unanimity rules, we examine simple majority rules to decide on a set of allocational rules. It is possible to propose and agree upon rules that distribute rights to future benefits only to those who compose a minimal winning coalition in a collective-choice arena. Symmetric players in an operational game with inefficient outcomes may find that using rules to change the structure of that game to improve outcomes also creates substantial inequalities. To isolate the impact of the voting rule itself, we have chosen first to study symmetric groups before tackling the problems of asymmetric groups.

In this paper, we first present the theoretical predictions and parameterizations for two base games—the constituent common-pool resource game and the voting game in which proposals to change the structure of the constituent game are made and voted upon. Our experimental groups are relatively small in size—7 persons. The complexity involved—as will be discussed below—in the proposal space for even 7 participants is immense. By not allowing face-to-face communication in this complex multilevel game, we approximate aspects of larger field settings.[7] The players in these series of experiments face symmetric payoffs in the constituent common-pool resource game. Future research will focus both on asymmetric interests and on larger groups, but as the reader will see, the strategy space involved in this study is already substantially greater than in most earlier studies of collective action. By constraining the size and difference among players, we can more clearly examine how differences in the voting rules used by symmetric players in an ongoing commons dilemma game affect the allocation rules they adopt.

II. A CPR Model

In this section, we specify the game played by n appropriators on the CPR. Appropriator i withdraws an amount x_i from the CPR. Let $X = \sum x_i$ be the total group withdrawal from the CPR. For example, x_i could be water pumped to the surface and used for agricultural production. For narrative ease, we use this interpretation. The instantaneous benefit accruing to appropriator I, B_i, is given by the following quadratic function:

$$(1) \qquad B_i(x_i) = ax_i - bx_i^2,$$

where a and b are positive constants. This equation implies diminishing returns to production at the surface, an assumption that accords with production experience from CPRs, such as the Ogallala aquifer (Kim et al., 1989). Appropriators are homogeneous, so the benefit function given in (1) applies to each appropriator I. In addition, the benefits received by an appropriator are independent of the extraction of other appropriators.

The total cost of pumping water incurred by appropriator i, $C_i(x_i,X)$, depends both on his or her appropriation and on total appropriation. $C_i(x_i,X)$ is simply the product of the amount withdrawn by i, x_i, and the average cost (expressed in cents) of pumping water (AVC), which is given by

$$(2) \qquad AVC = c + k(X-1)/2,$$

where c is the base cost of extraction at the initial depth-to-water and k is a positive cost parameter linking extraction cost to depth-to-water.[8] Thus, the cost function is

(3) $C_i(x_i,X) = x_i(c + k(X-1)/2)$.

Again, we assume that each appropriator faces the same cost function. In order for the resource to have economic value, it is necessary that the following condition on the parameters of the net benefit function be satisfied:

(4) $a > c - k/2$.

Inequality (4) guarantees a positive net benefit to the first unit of water withdrawn from the aquifer and will be assumed throughout.

It is important to note that the cost function defined by (3) introduces an externality into the model. The extraction of a unit of water by one appropriator will increase the average cost incurred by each appropriator by k/2. Because of this externality, one would expect the individually rational extraction level to diverge from the socially optimal level. This intuition will be verified in the optimal and equilibrium solutions that follow.

The benefit and cost functions (1) and (3) define a utility function for an n-player game in normal form. For player i, the utility function $u_i(x)$, which is in general a function of the entire vector x of strategies chosen by all the players, is given by

(5) $u_i(x) = B_i(x_i) - C_i(x)$

$= ax_i - bx_i^2 - x_i(c + k(X-1)/2)$.

There are many settings in which the players could choose the x_i. Before proceeding with a theoretical framework for investigating player choices of x_i, we introduce the parameterizations and specific institutions faced by the players in our experimental investigation.

Parameters and Design

As illustrated in Figure 1, each experiment consists of two stages: Stage I and Stage II. In Stage I, players face a default decision setting; each player chooses his/her strategy x_i simultaneously, without any form of communication. In Stage II, players face a situation in which x_i is chosen after the functioning of a voting mechanism. In addition, our overall experimental design included two phases: Phase I and Phase II. There are three principle differences between Phase I and Phase II: (1) the benefit functions utilized, (2) the incremental cost per token, and (3) the voting institution utilized. Table 1 reports key parameters utilized in the two phases. Before turning to the theoretical solutions linked to the parameterizations, we first discuss the details of the decision setting in Stage I and Stage II. The details of the decision settings are presented from the perspective of the information received by the subjects in our experiments.

The Stage I Setting

The baseline strategy space can be summarized as follows. Subject i makes a decision x_{it} in each round t. The decision x_{it} is restricted to integer values with a lower bound of 0 and an upper bound of 80. The units of the decision are called "tokens." Payoffs according to the net benefit function are evaluated at integer values of the arguments of that function.

The decision task can be summarized as follows:

> Each subject has a single decision to make each round, how many tokens to order. Each knows their own individual benefit function (expressed in tabular form) and that all individuals face the same benefit function. A base token cost of $0.01 is stipulated for each decision round. The instructions explain that the token costs increase by $0.01 for each token ordered by the group and that the token cost for each individual in a given round is the product of the average token cost for that round and the number of tokens each individual orders in that round.[9] All subjects make purchasing decisions simultaneously. After each decision round, subjects are informed of the total number of tokens ordered by the group, the cost per token for that round, and their profits for that round. Subjects are not informed of individual token orders.

The Stage II Setting

Stage II begins with an announcement that decision rounds that follow include the opportunity for each individual to propose a token order for every member of the group and the opportunity to vote on all proposals.

Simple Majority Voting: Subjects receive the following instructions.

1. Prior to each decision round, you will be asked to make a **proposal** for **token orders** for the **entire group.** More specifically, you will fill out a form where you **propose** a token order for each person in the group.

2. Every person in the group will privately fill out a "proposal form." The proposal forms will be collected, tabulated, and displayed on an overhead to the group. Each person's proposal will be identified by that person's experiment ID-Number—but, **not** by that person's name.

3. After the experimenter displays the proposals to the group, each person will privately **vote** on a proposal.

4. If a proposal **receives a majority** of the votes **(it receives 4 or more),** that proposal will be **adopted and implemented** for that decision round. That is, the experimenter will place a token order for each person. The token orders made for each person will correspond to the **approved proposal.**

5. If a proposal **does not receive a majority** of the votes (it receives 3 **or less),** each person will make their own token order for that decision round.

Special Considerations:

1. You are allowed to make a proposal that has the same token order for each person or you can propose different orders for different persons.

2. If 2 or more individuals make exactly the same proposal, the experimenter will count that proposal as one proposal and note on the display the ID-Numbers of the individuals making that proposal.

3. There will be a new proposal and new vote before each decision round, until you are told otherwise.

Simple Majority Voting—Symmetric Proposals: Conditions are the same as with "simple majority voting," except that subjects are required to make a proposal in which all individuals make the same token order.[10]

Unanimity Voting: Conditions are the same as with "simple majority voting," except that for a proposal to be adopted and implemented it has to receive unanimous approval.

Game Solutions for Stage I

The equilibrium of this game requires that each appropriator maximize individual payoffs taking the actions of others as given. In particular, each appropriator, I, solves a maximization problem of the form:

(6) maximize $u_i(x)$ wrt x_i,

where u_i is given in equation (5). At a maximum, appropriator i faces the following first order condition:

(7) $0 = a - 2bx_i - x_i(k/2) - (c+k(X-1)/2)$.

Since the game is symmetric, it has a symmetric equilibrium.[11] At this symmetric equilibrium, one has that $X=nx_1=nx_2=\cdots=nx_n$. In particular, at this equilibrium, individual extraction is given by

(8) $x_i^e = (a - c + k/2)/(2b + (n+1)k/2)$.

The equilibrium value of the resource to appropriator i, $V_i(x^e)$, results when each appropriator chooses to extract at the level given in (8) and is given by

(9) $V_i(x^e) = (2b+k)(a-c+k/2)^2/(2[2b+(n+1)k/2]^2)$.

We now turn to the optimal solution of the game, and contrast it to the game equilibrium just derived.

The optimal solution of the constituent game is the set of extraction levels, $<x_1,x_2,\cdots,x_n>$, that maximizes total group payoff. This solution is derived by solving a single maximization problem of the form:

(10) maximize $\sum_i u_i(x)$ wrt $<x>$.

Each of the n first-order conditions for the maximization of (10) takes the following form:

(11) $0 = a - 2bx_i - X(k/2) - (c + k(X-1)/2)$.

Note the difference between (11) and (7), which already establishes that the game equilibrium is not an optimum. The system of equations (11) has a symmetric solution x°, a typical component of which is given by

(12) $x_i^\circ = (a - c + k/2)/(2b + nk)$.

Comparing (8) and (12), one sees that $x_i^e > x_i^\circ$ for $n>1$; thus, the suboptimality of the game equilibrium results from the players withdrawing too much of the resource.

The optimal value of the resource to each player, $V_i(x^\circ)$, is given by substituting the optimal solution into the player's utility function. The result is

(13) $V_i(x^\circ) = (a-c+k/2)^2/(2[2b + nk])$.

Denote by E the coefficient of efficiency in resource utilization. E is measured by the ratio of equilibrium value to optimal value, whence

(14) $E = V_i(x^e)/V_i(x^\circ)$

$= (A + 4n)/(A + (n+1)^2)$,

where A represents the expression $(2b/k)(2b/k + n + 1)$. From (14), it is clear that $E=1$ when $n=1$, that $E<1$ for $n>1$, and that E approaches 0 and n approaches infinity. Thus, in the limit, the presence of multiple users leads to complete dissipation of CPR rent.

Table 1 displays the actual parameter values used in Phase I and Phase II of our experiments. Also displayed are the game and optimal solutions for Stage I in Phase I and Phase II. As displayed, in Phase I, the game equilibrium is a token order of 14 by each subject (paying each subject \$2.35 in computer dollars), while the optimal solution is a token order of 9 by each subject (paying each subject \$3.40 in computer dollars). This token order difference implies an efficiency of 69.1% at the Nash equilibrium. In Phase II, the game equilibrium is a token order of 12 by each subject (paying each subject $4.32 in computer dollars), while the optimal solution is a token order of 7 by each subject (paying each subject $8.82 in computer dollars). This token order difference implies an efficiency of 49.0% at the Nash equilibrium.

Game Solutions for Stage II

In Stage II, the decisions in the baseline game are imbedded in a voting game. The voting game is itself divided into two parts. In the first part, proposals are made; in the second part, a vote is taken over the proposals that have been made. The outcome of the voting game is either a vector of token orders that is binding on each player or an opportunity to play one round as if in Stage I. The difference depends on whether a proposal is adopted or not.

In the proposal part, each player gets to make one proposal from the space of proposals P. P is the set of all n-dimensional vectors $x = (x_1,\ldots,x_n)$, with individual component x_i an integer subject to upper and lower bounds.[12] In both Phase I and Phase II, the lower bound on x_i is 0; the upper bound, 80. This yields 81^7 (roughly 23 trillion) elements of P.[13]

Let x(I) be the proposal chosen by player I. Let X(P) denote the set of all proposals that have been made. There can be as many as n proposals in X(P), but there may be less in the event that the same proposal is made by more than one player. Once each player i has chosen a proposal x(i), then play enters the voting part. In this part, the players vote on the proposals in X(P). Each player gets one vote, which can be allocated to exactly one of the proposals. A player does not have to vote for his or her own proposal.

There are various ways that votes can be taken over X(P), two of which are considered in this paper. **Simple majority rule** means that if a proposal x in X(P) gets a strict majority (more than half the possible votes), then that proposal is implemented by the experimenter, and player i receives the payoff $u_i(x)$. If no proposal receives a majority, then there is no decision and players choose their token orders as if they were in Stage I. **Unanimity rule** means that if a proposal x in X(P) gets all the votes, then that proposal is implemented by the experiment. Let X#(P) denote the alternative chosen from the set of proposals X(P). For both of these methods of voting, X#(P) has at most one member. X#(P) is empty under simple majority rule when no alternative receives a majority of votes; and under unanimity rule, when no alternative receives all the votes.

The voting game has considerable strategic content. Each player has a pair of strategies, namely what to propose, and once proposals have been made, what to vote for. Since no write-ins are allowed, if a player wants to be sure of getting to vote for a proposal, that player must make that proposal. In what follows, we will make the following assumptions on players.

(15) Players are individually rational.

Their proposal and voting behavior is driven by a desire to achieve higher payoffs than those available from the underlying game equilibrium. In terms of the model, this amounts to the inequality

(16) $u_i(x(I)) \geq u_i(x^e)$

for any proposal x(i) in X(P) and for any proposal x actually chosen.

(17) Players are group rational.

Any proposal x made and voted for is a Pareto optimum. In terms of the model, this means that there is no vector y in P such that

$u_i(y) > u_i(x)$

for all players I. The set of Pareto optimal proposals is a complicated n-1 dimensional subset of P.

These two restrictions together imply that the set X(P) of proposals actually made will consist only of individually rational Pareto optima. However, they still leave open plenty of possibilities. With $n = 7$, a lower bound on token orders of 0 and an upper bound of 80, there are still over 100 billion proposals available in P, that could appear in X(P).

We also apply these same assumptions to voting behavior. That is, a player will only vote for a proposal x if that vote is individually rational, if the proposal x pays the player better than the game equilibrium x^e would. This assumption has an impact. Consider the case of ideal points. Player i's ideal point, written x_i^*, is the vector in P which maximizes i's utility. It is easy to show that the only component of x_i^* which is positive is the i-th component; all the rest of the components are zero. Thus, if player i were a selfish dictator, he or she would shut down all other producers and then maximize all by his- or herself. Consider, for instance, the Phase I problem

maximize $u_1(x)$

subject to x feasible. This maximum occurs at the vector

$$x_1^* = (32,0,0,0,0,0,0)$$

and similarly for any player other than 1. Player 1's utility at his or her ideal point is

$$u_1(x_1^*) = \$11.90,$$

the highest payoff that player 1 could possibly receive. For all the other players j,

$$u_j(x_1^*) = 0.$$

Thus, the utility to any other player from 1's ideal point is zero. Individual rationality then says that no player j will vote for another player i's ideal point if that ideal point is proposed. An analogous calculation for Phase II shows that player 1's ideal point is

$$x_1^* = (43,0,0,0,0,0,0,0)$$

with a payoff of

$$u_1(x_1^*) = \$53.89.$$

We also assume that a player only votes for Pareto optima. This assumption has no additional impact, however, if only Pareto optima are proposed in the first place.

We now turn to **strict majority** rule for the two phases. Suppose there are n players, any m of whom constitute a majority. A **Condorcet** proposal has a majority against every other proposal, that is, m players vote for it. As is well known, if there exists a Condorcet proposal, it is unique, and that proposal equals the core of the voting game. A Condorcet proposal provides a very attractive prediction for this game.[14] We assume the following:

(18) Condorcet assumptions. If x is a Condorcet proposal, then it is proposed and belongs to X(P). Moreover, if x is a Condorcet proposal in X(P), then every player that favors x votes for x and x is chosen.

We will see the force of this assumption in the case of strict majority rule with symmetric proposals. However, with asymmetric proposals permitted in both Phases I and II, for strict majority rule, there is no Condorcet proposal.[15]

The lack of a Condorcet proposal motivates the search for other solution concepts. A natural concept for this game is that of a **minimal winning coalition** (Riker, 1962). Consider a set of players with exactly m members. This is a minimal winning coalition if they all vote for the same proposal. Now consider the special case of a proposal **x(S)** with the following properties:

$x_i(S) = 0$ for i not in S.

The payoffs associated with $\sum x_i(S)$, i in S, are maximal.

What the proposal **x(S)** does is produce the Pareto optimum that is best for the members of S, and which excludes nonmembers of S from payoffs. For Phase I, we can construct a typical **x(S)** as follows. Let $S = \{1,2,3,4\}$. From the optimal value formula (12) with $n = 4$, one has

$x_i = 14$, $i = 1,2,3,4$.

For the three players outside the majority, one has $x_j = 0$. Each member of the majority makes \$5.29, on revenues of \$9.28 and costs of \$3.99. The entire coalition makes 4(5.29) = \$21.03. Compared to the optimal value of \$23.81, this represents an efficiency of 88.3%. For Phase II, an analogous calculation yields

$x_i = 12$, $i = 1,2,3,4$,

with each member of the majority making \$15.12. The implied efficiency of this token order is \$60.48/\$61.74, or 97.1%.

In the event that there is no Condorcet alternative, we assume the following:

(19) Minimal Winning Coalition, weak version. If the vector **x(S)** is in X(P), and there is no other proposal **x(S')** in X(P) that includes the members of S, then the members of S vote for **x(S)**.

This simply says that if the best vector for S is available to vote on, and no other competing proposals are available to the members of S, then the members of S vote for their best vector.

We call this assumption weak because is does not say that x(S) will necessarily be proposed, nor does it say that only x(S) will be available. It is an open matter whether anyone will think to propose any of the vectors x(S) (for n = 7, there are 35 such vectors to choose from), to say nothing of whether more than one such proposal may be present among the proposals in a given round. Nevertheless, given the repeated nature of the voting, we hypothesize that some x(S) will eventually be chosen under majority rule.

(20) Minimal Winning Coalition, strong version. As the end of the game is approached, a minimum winning coalition S will propose the coalition optimal x(S), and vote for x(S) as well. Once x(S) is elected, it will be proposed and adopted in subsequent play of the voting game.

If this hypothesis is not reflected in the data, then we expect to see the cyclical turbulence first discovered by McKelvey (1979).

We now turn to **majority voting with symmetric proposals,** so that the space of proposals P is drastically reduced. The voting game now has a Condorcet proposal, x°, namely the symmetric Pareto optimum.[16] Thus, according to assumption (20), we expect that x° will be proposed, and then elected, in majority voting with symmetric proposals.

Finally, we turn to **unanimity voting,** once again with the full proposal set P. Under unanimity voting any suboptimal outcome is defeated by some Pareto optimum. Thus, X#(P) could be any Pareto optimum. Moreover, the minimal winning coalition is the grand coalition. So by analogy with x(S), we let x(N) denote the proposal that is best for the grand coalition. Clearly x(N) = x°. Appealing to our assumption (20) of minimal winning coalition, we expect that x(N) will be proposed, and then elected, in unanimity voting. Thus, we expect to observe the same outcomes under majority voting with symmetric proposals and under unanimity voting.

III. The Experimental Setting

Parameters

As discussed above, the experiments consist of two design configurations: Phase I and Phase II. Key parameters for each design are reported in Table 1. There are three principle differences between Phase I and Phase II: (1) the benefit function utilized in Phase I generated an efficiency at the Nash equilibrium of 69.1 % of optimum, while the benefit function used in Phase II generated a Nash efficiency of 49.0% of optimum; (2) all subjects in Phase II experiments had participated in Phase I experiments; and (3) while Phase I experiments focused only on simple majority voting, Phase II investigated simple majority voting, simple majority voting with symmetric proposals, and unanimity voting. Thus, IN Phase II subjects are experienced in the voting game and face a more severe dilemma from the perspective of noncooperative game theory.

Subjects

All experiments were conducted at Indiana University, utilizing the NovaNet computer system. Volunteers were recruited from undergraduate introductory economics courses.[17] Before volunteering, subjects were informed they would participate in a decision-making experiment, would be paid in cash an amount dependent upon their decisions and the decisions of others in the experiment, and could expect the experiment to last between 1 and 1.5 hours.

Upon arriving at the experiment, subjects were randomly assigned to computer terminals and received a briefing of experiment procedures, including the fact that all decisions and earnings were private information. Subjects then proceeded to privately study a series of instructions explaining the decision task, with the opportunity to ask the experimenter a question at any time. Subjects in Phase I were experienced in the constituent game of Stage I, but were not experienced in the Stage II voting game. As noted above, subjects in Phase II had participated in Phase **I.**[18]

The Decision Setting

As discussed earlier, experiments consisted of two 10-round decision stages. Stage I represented a "no voting baseline" in which subjects made decisions privately with no intervention between decision rounds.[19] Before entering Stage I, subjects were informed of the number of decision rounds in Stage I, but not that there would be a second stage to the experiment. In Stage II, subjects were informed of a change in procedures that allowed for the introduction of one of the voting institutions. Before entering Stage II, subjects were informed of the number of decision rounds in Stage II and that the experiment would end after Stage II.

Experimental Results: Phase I

Results are reported from four Phase I experiments. The discussion of results is organized around three areas: (1) outcome efficiencies, (2) proposals and voting, and (3) summary observations. [20]

Outcome Efficiencies

Figure 2 displays efficiencies for each of the experiments. Two observations are important. In Stage I decisions, efficiencies tend to be distributed around the predicted Nash efficiency of 69.1%, averaging 58.7% of optimum. In three of four experiments, efficiencies increase dramatically with voting, especially experiments 2 and 3. Across all four experiments, Stage II efficiencies averaged 82.9% of optimum.

Proposals and Voting

As a benchmark for discussion purposes, we discuss proposals in relation to: (1) the symmetric proposal x(N) that would maximize group payoffs, hereafter referred to as (SYM°), a proposed token order of 9 tokens per subject, and (2) an asymmetric proposal x(S) that suggests an attempt at the formation of a minimal coalition and maximizes the coalition's earnings, hereafter referred to as (MWC^0), a proposed token order of 14 by each member of the coalition and 0 by each nonmember. As expected, early rounds of all experiments exhibited considerable variation in proposed token orders. In the discussions that follow, we highlight what we infer as the basic trends observed in each of the experiments.

Experiment 1: This experiment began with six different proposals. No individual proposed SYM°, while one individual proposed MWC^0. There were four symmetric proposals, two at all 14s, one at all 13s, and one at all 10s. The remaining two asymmetric proposals had no clear pattern. Voting was broadly distributed across proposals, with only the symmetric proposal of all 13s getting more than one vote, receiving two. Round 2 showed a similar pattern of proposals, with no proposals at SYM° and two distinct proposals at MWC°, each proposing different coalitions. Voting remained scattered, with one of the MWC^0 proposals getting two votes and a proposal of all 10s getting two votes. By the round 3, there were three identical proposals at MWC^0 (receiving three votes) and one proposal at SYM° (receiving two votes). In round 4, there were three proposals at MWC^0, but only two proposed the same coalition. In this round, there were two proposals at SYM° (receiving three votes). In round 5, there were three proposals at MWC°, proposing two different coalitions. One received three votes. There were two proposals at SYM°, receiving two votes. Rounds 6 and 7 went much like round 5. In round 8, we observed the first successful coalition, interestingly a coalition different from the one getting three votes in round 5. The other three voters cast a vote for SYM°. In the last two rounds, the coalition from round 8 was able to successfully pass the same proposal of MWC^0. See Appendix A for a more detailed discussion of this experiment, focusing on the process of arriving at coalitions through signaling.

Experiment 2: This experiment began with five different proposals. No individual proposed SYM° or MWC^0. There were, however, three identical symmetric proposals of all 10s, receiving five votes. Round 2 showed a similar pattern of proposals, with one of the symmetric proposals at SYM°, receiving four votes. Round 3 yielded a similar result. In round 4, there were three proposals at SYM°, receiving three votes, and two at a symmetric proposal of all 8s, receiving two votes. In the remaining rounds, the group successfully adopted SYM°. By round 9, all subjects were proposing SYM°. One of the major differences in experiment 2, relative to experiment 1, was the lack of "minimal coalition forming" proposals. Across 80 proposals, only 4 showed the pattern of proposing a minimal coalition and none of these were at MWC^0.

Experiment 3: This experiment began with six different proposals. Two were at SYM°, and none at MWC^0. In total, there were four symmetric and three asymmetric proposals. None of the asymmetric proposals followed a pattern consistent with a minimal coalition. No proposal received more than two votes. Round 2 showed a similar pattern, except that one asymmetric proposal (10,10,10,5,10,10, 10) received four votes. This coalition was again successful in round 3. In round 4, no proposal received a majority. Three members of the MWC of rounds 2 and 3 were lured to other proposals offering them the same number of tokens (10), but in a proposal that involved lower average token costs. Votes were scattered over four different asymmetric proposals, none having the pattern of a minimal coalition. In round 5, the asymmetric proposal (11,11,1,11,11,11,11) received four votes. In round 6, votes were again scattered over four different proposals. In round 7, the proposal (10,10,1,10,10,10,10,10) received four votes. In rounds 8, 9, and 10, no proposal received a majority. Votes were again scattered over four, five, and four proposals, respectively.

Experiment 4: This experiment began with six different proposals. No individual proposed SYM° nor MWC^0. There were three symmetric proposals and four asymmetric proposals, none proposing a minimal coalition. Voting was dispersed over three proposals. Rounds 2 through 7 showed a similar pattern of proposals and voting. Not until round 7 did a proposal of SYM° occur. It received two votes. In rounds 8 and 9, SYM° was adopted. In round 10, however, the majority was disrupted by a split over all 9s versus all 10s. Each of these two proposals received three votes.

Figure 3 summarizes key aspects of proposals and voting in the Phase I experiments.[21] The six panels are frequency distributions organized around proposals (P) and voting (V), where observations are pooled across all Phase I experiments. Appendix B contains similar information for each individual experiment. Several benchmarks are useful for interpreting the data; individual earnings at the game equilibrium are $2.35 per round, at SYM° they are $3.40 per round, and at MWC^0 they are $5.29 for each coalition member.

Beginning with the two panels in the upper right-hand corner (IP and IV), the distribution of proposals and voting are displayed in relation to an individual's earnings with respect to their own proposal and in relation to the votes that they cast. Both distributions are uni-modal. In IP and IV, the highest frequency (46.4% and 48.9%, respectively) falls between $3.50 and $4.00. At this level of pooling, the mode supports SYM° as the benchmark with the most appeal. At the same time, there is considerable proposal and voting activity for proposals tending toward MWC^0. In particular, as seen in the data in Appendix B, in experiment 1 the mode is at $5.50. Panels 2V and 2P display complementary information regarding the proposal and voting patterns. In particular, on a per round basis, frequencies are displayed for four categories of proposals: those classified as having a minimal winning coalition structure (MWC) and the subset of MWC proposing maximal coalition earnings, MWC^0 ; and similarly those classified as having a symmetric structure (SYM) and the subset of SYM proposing maximal group earnings, SYM°. On average, 55.7% of all proposals (53.2% of all votes) are symmetric. These percentages are relatively stable over the ten rounds. At the same time, however, the percentage of SYM^0 proposals rises dramatically across rounds from 7.1 % to 42.9% (3.6% to 39.3% for votes). A similar pattern is observed for coalition proposals and voting. Specifically, MWC rises from 3.6% to 28.6% (3.6% to 21.4% for votes). With percentages this low, it is not surprising that so few successful MWCs were observed.

Panels 3P and 3V display data on the efficiencies of proposals and votes, respectively. Recall, the efficiency of the game equilibrium is 69 %. The overwhelming majority of both proposals and subsequent votes lies beyond 69% efficiency. Indeed, the mode is in the 95%-100% range for both proposals and votes (56.4% and 60.0%, respectively). Similarly, on a round-by-round basis, Panels 4P and 4V display frequencies in relation to an individual's earnings with respect to their own proposal and in relation to the votes that they cast compared to what they would earn at the game equilibrium. Consistent with the assumption of individual rationality, subjects regularly make proposals and votes that yield own earnings higher than those at the game equilibrium. The overall averages are almost 90% and, by the end of the experiment, 100%.

Summary Observations: Phase I

The Phase I experiments led to several key summary observations across all experiments.

Observation 1—Overall Proposals and Voting at the individual level: There was great diversity in subjects' proposals and subsequent votes. The vast majority of proposals and votes, however, was for outcomes that would yield efficiencies significantly better than the game equilibrium. Although there was considerable attraction to SYM^0, this benchmark was not dominant. On the other hand, on a round-by-round basis, proposal of (and voting for) both SYM^0 and MWC^0 increases.

Observation 2—Outcomes at the group level: While Stage I efficiencies averaged 58.7% of optimum, Stage II efficiencies averaged 82.9% of optimum. In 45 % of all rounds a proposal was elected. Only 27.5 % of these adopted proposals were SYM, and of these 25 % were at SYM^0. Only 7.5 % of these adopted proposals were MWC, all of which were strictly MWC^0.

Experimental Results: Phase II

Results are reported from six Phase II experiments, two each from the design conditions of simple majority rule, simple majority rule with symmetric proposals, and unanimity rule. As with Phase I, the discussion of results is organized around three areas: (1) outcome efficiencies, (2) proposals and voting, and (3) summary observations. Proposals, voting, and summary observations are discussed separately for each voting institution. Again, as a benchmark, proposals are discussed in relation to the symmetric proposal that would maximize group payoffs (SYM°), a proposal token order of 7 tokens per subject. In the simple majority rule experiments that allowed for asymmetric proposals, asymmetric proposals that maximize minimal coalition earnings (MWC°) are also considered. In Phase II, MWC° implies a proposed order of 12 by each member of the coalition and 0 by nonmembers.

Outcome Efficiencies

Figure 4 displays efficiencies for each of the six experiments across the three voting institutions. Two observations are important. Stage I decisions led to efficiencies that were biased downward relative to the predicted Nash efficiency of 49%. Across all six experiments, Stage I efficiencies averaged 39.3% of optimum. In all experiments, efficiencies increased with voting. There appeared, however, to be a significant "institutional" effect. The two simple majority rule experiments generated Stage II efficiencies averaging 68.2% of optimum. The two simple majority rule experiments requiring symmetric proposals generated average efficiencies of 99%. The two unanimity experiments generated average efficiencies of 91%.

Proposals and Voting: Simple Majority Rule

Similar to the discussions above, we highlight what we infer as the basic trends observed in each of the experiments.

Experiment 1: This experiment began with six different proposals. No individual proposed SYM°, while one individual proposed MWC°. There were three symmetric proposals, two at all 10s and one at all 11s. Two asymmetric proposals had an obvious coalition pattern, one at MWC° (12,12,0,0,0,12,12) and another at (0,0,0,13,13,13,13). The symmetric proposal of all 10s received four votes and was implemented, generating an efficiency of 81.6%. The second round proposals were quite interesting. There was one proposal at SYM°, one proposal at all 10s, and one proposal at all 11s. Three of the remaining proposals had minimal coalition patterns, two at (0,0,0,13,13,13,13), and one at (0,0,0,12,12,12,12). The remaining proposal was

(9,10,9,10,9,10,9). The proposal (0,0,0,13,13,13,13) received three votes while SYM° received two of the remaining four votes. Subject 4 did not support the minimal coalition, voting instead for their own proposal of all 1 Is. Round 3 was similar to round 2. There were only two symmetric proposals, none at SYM°. There were five minimal coalition proposals (two were the same), with one at MWC°. Voting was dispersed, with no proposal receiving more than two votes. Round 4 was quite different. There were two symmetric proposals, one at SYM°. There were four minimal coalition proposals. Three were identical, however, at (13,0,0,0,13,13,13). This proposal was adopted and sustained for the next four rounds. In round 8, one member of the coalition defected to another coalition, (0,0,0,12,12,12,12). In that round, no proposal received a majority of votes. In rounds 9 and 10, a new coalition was formed at (0,0,0,12,12,12,12), receiving four votes in each round.

Experiment 2: This experiment began with 6 different proposals. No individual proposed SYM°, while two individuals proposed MWC°. There were four symmetric proposals, two at all 10s, one at all 15s, and one at all 8s. Three asymmetric proposals had an obvious coalition pattern, one at MWC° (12,12,12,12,0,0,0), another at (0,0,0,12,12,12,12), and another at (1,1,9,9,9,9,1). No proposal received more than two votes. In round 2, three subjects proposed a symmetric proposal of all 8s, while two subjects once again proposed minimal coalition proposals. The symmetric proposal of all 8s received three votes, the other four votes were distributed across four different proposals. Round 3 was similar to round 2. The symmetric proposals of all 8s received three votes, while a minimal coalition proposal of (12,12,12,0,0,0,12) also received three votes. Round 4 was similar except that the coalition of (12,12,12,0,0,0,12) picked up its fourth vote, with the other three subjects supporting the symmetric proposal of all 8s. The coalition was sustained through round 7. In rounds 8 through 10, the group was split only by indecision over a proposal of (13,13,13,0,0,0,13) versus (12,12,12,0,0,0,12), never again finding a majority over either proposal. Interestingly, in this experiment, following round 5, there was never a symmetric proposal. Every proposal in rounds 6 through 10 had a minimal coalition pattern.

As in Figure 3, Figure 5 summarizes key aspects of proposals and voting in the Phase II experiments with simple majority rule. Several benchmarks are useful for interpreting the data; individual earnings at the game equilibrium are $4.32 per round, at SYM° they are $8.82 per round, and at MWC° they are $15.12 for each coalition member.

In IP and IV, the highest frequency of proposals and voting (65.0% and 67.9%, respectively) falls between $14.50 and $16.00. At this level of pooling, the mode supports MWC° as the benchmark with the most appeal. As shown in Panels 2V and 2P of Figure 5, on average 21.4% of all proposals (20.0% of all votes) are symmetric. These percentages, however, fall dramatically from 57.1 % to 0% for both proposals and voting over the ten decision rounds. A different pattern is observed for coalition proposals and voting. Specifically, MWC proposals rise from 35.7% to 85.7% (42.9% to 85.7% for votes). With percentages this high, it is not surprising that so many successful MWCs were observed.

As shown in Panels 3P and 3V of Figure 5, the overwhelming majority of both proposals and subsequent votes lies beyond the 49% efficiency of game equilibrium. Indeed, the mode is in the 95%-100% range for both

proposals and votes (75.7% and 83.6%, respectively). As shown in Panels 4P and 4V, on a round-by-round basis, subjects consistently make proposals and votes that yield own earnings higher than those at the game equilibrium. The overall averages are over 90%.

Summary Observations Phase II: Simple Majority Rule

The Phase II, simple majority rule experiments led to several key summary observations.

Observation 1—Overall Proposals and Voting at the individual level: There was great diversity in subjects' proposals and subsequent votes. The vast majority of proposals and votes, however, were for outcomes that would yield efficiencies significantly better than the game equilibrium. Unlike Phase I experiments, there was considerable attraction to MWC°. In fact, both experiments stabilized at MWC°.

Observation 2—Outcomes at the group level: While Stage I efficiencies averaged 38.2% of optimum, Stage II efficiencies averaged 68.2 % of optimum. In 55 % of all rounds a proposal was elected. Only 5 % of these adopted proposals were SYM, and 0% were at SYM°. Fifty percent of these adopted proposals were MWC, of which 30% were strictly MWC^0.[22]

Proposals and Voting: Simple Majority Rule with Symmetric Proposals

The requirement that all proposals were constrained to symmetric orders changed things dramatically.

Experiment 1: In round 1 of this experiment, six of seven proposals were at all 10s and one at all 9s. The proposal of all 10s received four votes. In round 2, two subjects proposed SYM^0 at all 7s, four proposed all 9s, and one proposed all 8s. SYM^0 received five votes. SYM^0 was supported until the end of the experiment. By round 4, it was the only proposal.

Experiment 2: In round 1, three subjects proposed SYM° and the proposal of all 7s was adopted and sustained through round 5. In round 6, a majority supported a proposal of all 8s. In rounds 7 through 10, the group returned to SYM^0.

As in Figure 5, Figure 6 summarizes key aspects of proposals and voting in the Phase II experiments with simple majority rule and symmetric proposals. The benchmarks remain the same. Both distributions are uni-modal. In IP and IV, the highest frequency of proposals and voting (87.9% and 91.4%, respectively) falls between $8.50 and $10.00. At this level of pooling, the mode supports SYM° as the benchmark with overwhelming appeal. As shown in Panels 2V and 2P of Figure 6, 75.7% of all proposals are SYM° (80% of all votes). Also note that the percentage of SYM^0 proposals rises sharply from 21.4% to 100% (28.6% to 100% for votes).

As shown in Panels 3P and 3V of Figure 6, the overwhelming majority of both proposals and subsequent votes lies beyond the 49% efficiency of game equilibrium. Indeed, the mode is in the 95%-100% range for both

proposals and votes (87.9% and 91.4%, respectively). As shown in Panels 4P and 4V, on a round-by-round basis, subjects consistently make proposals and votes that yield own earnings higher than those at the game equilibrium. The overall averages are almost 100%.

Summary Observations Phase II: Simple Majority Rule with Symmetric Proposals

The Phase II, simple majority rule experiments with symmetric proposals led to several key summary observations.

Observation 1—Overall Proposals and Voting at the individual level: There was almost no diversity in subjects' proposals and subsequent votes. The vast majority of proposals and votes were for SYM°

Observation 2—Outcomes at the group level: While Stage I efficiencies averaged 33.4% of optimum, Stage II efficiencies averaged 99% of optimum. In 100% of all rounds a proposal was elected. Ninety-five percent were at SYM°.

Proposals and Voting: Unanimity Rule

As expected, relative to simple majority rue, the unanimity rule led to a sharp increase in symmetric proposals.

Experiment 1: Round 1 began with seven different proposals. All but one was symmetric, with one at SYM°. No proposal received more than two votes. In round 2, all proposals were symmetric with four subjects proposing SYM°. The proposal of all 7s received six votes and was supported for the duration of the experiment. By round 4, it was the only proposal.

Experiment 2: Round 1 began with three different symmetric proposals, with four subjects proposing SYM°. SYM° received five votes in round 1, six votes in round 2, seven votes in round 3, and by round 4 it was the only proposal.

As in Figure 6, Figure 7 summarizes key aspects of proposals and voting in the Phase II experiments with unanimity rule. The benchmarks remain the same. In IP and IV, the highest frequency of proposals and voting (91.4% and 95.0%, respectively) falls between $8.50 and $10.00. At this level of pooling, the mode supports SYM° as the benchmark with overwhelming appeal. As shown in Panels 2V and 2P of Figure 7, 98.6 % of all proposals are SYM (100% of all votes). 88.6% of all proposals are SYM° (93.6% of all votes). Also note that the percentage of SYM° proposals rises sharply from 35.7% to 100% (50.0% to 100% for votes).

As shown in Panels 3P and 3V of Figure 7, the overwhelming majority of both proposals and subsequent votes lies beyond the 49% efficiency of game equilibrium. Indeed, the mode is in the 95%-100% range for both

proposals and votes (91.4% and 95%, respectively). As shown in Panels 4P and 4V, on a round-by-round basis, subjects consistently make proposals and votes that yield own earnings higher than those at the game equilibrium. The overall averages are 100%.

Summary Observations Phase II: Unanimity Rule

The Phase II, unanimity rule experiments led to several key summary observations.

Observation 1—Overall Proposals and Voting at the individual level: There was almost no diversity in subjects' proposals and subsequent votes. The vast majority of proposals and votes were for SYM°-

Observation 2—Outcomes at the group level: While Stage I efficiencies averaged 46.2% of optimum, Stage II efficiencies averaged 91% of optimum. In 95% of all rounds a proposal was elected, and all were SYM°.

IV. Conclusions

Voting is a commonly used formal institutional mechanism for determining rules to be used by larger collectivities of individuals. Previous studies of voting have generally concentrated on voting arenas without connecting the collective choices that are adopted in such arenas to subsequent games that individuals play within the rules decided upon in the voting arena. In this paper, we focused on multilevel games and experiments to examine how the voting rule used at one level affects the structure of an ongoing commons dilemma game at an operational level.

Without voting, aggregate behavior broadly followed the predicted pattern of game equilibrium with its attendant inefficiencies. With simple majority rule, subjects had a difficult (but not impossible) time finding partners for winning coalitions. Without any of the normal cues associated with group membership and political interaction, subjects tended to focus on symmetry or minimal coalitions. With simple majority rule limited to symmetric proposals or unanimity rule, subjects consistently adopted the symmetric optimum. In all cases, voting enhanced efficiency substantially.

Notes

1. The following books represent a summary of the progress that has been made. National Research Council, 1986; McCay and Acheson, 1987; Fortmann and Bruce, 1988; Wade, 1988; Berkes, 1989; Pinkerton, 1989; E. Ostrom, 1990; Sengupta, 1991; Blomquist, 1992; Bromley et al., 1992; Tang, 1992; Martin, 1989/1992; Thomson, 1992; Dasgupta and Mäler, 1992; V. Ostrom, Feeny, and Picht, 1993; Netting, 1993; and E. Ostrom, Gardner, and Walker, 1994).

2. Trying to obtain funding for designs that involve following a large set of empirical cases over time is extremely difficult even though the importance of such studies is universally acknowledged.

3. Isaac and Walker (1988, 1991) and E. Ostrom and Walker (1991, forthcoming) provide an overview of the relevant literature on repeated games with communication.

4. In an interesting "variation" of our communication experiments, Rocco and Warglien (1995) replaced face-to-face communication with communication via email. Subjects tended to come closer to optimum in their agreements, but had greater difficulty in conforming to the agreements they had made. See also Wilson and Herzberg (1988).

5. In large settings, the measured responses—which we have demonstrated help to enforce agreements in smaller settings—can be "washed out" by the noise of exogenous factors that affect all such resource systems.

6. See Putnam (1988) and Tsebelis (1990) who examined a different type of multilevel game. See Frohlich and Oppenheimer (1992), who asked subjects in an experimental setting to select principles of just distribution using face-to-face communication and unanimity or majority rule. In some of their experiments, subjects participated in a work setting where payoffs conformed to the principle of justice adopted. Also see Dawes et al. (1986) and Orbell and Wilson (1978a, 1978b).

7. We are not presuming that no communication occurs in larger groups, but rather that face-to-face communication among most participants is difficult in large groups. See Hoffman and Plott (1983) for an examination of the effect of pre-meeting discussions on coalition formation in majority rule committees.

8. The minus 1 in this expression reflects the fact that in the experimental design, X; is restricted to integer values.

9. In Phase II experiments, the base and incremental costs were $.05 per token.

10. See Cave and Salant (1995) for a discussion of a similar institutional setting where voting is over capacity utilization and the quota rate is the same for each firm.

11. The game also has asymmetric equilibria, which all lie within a small neighborhood of the unique symmetric equilibrium.

12. Upper and lower bounds on token orders are necessary for theoretical tractability and experimental control.

13. In the event that proposals must be symmetric, the number of possible proposals is drastically reduced to 81 such proposals.

14. For instance, a Condorcet proposal equals the core of the associated cooperative game.

15. The easiest way to prove this is to show that the core of the associated cooperative game is empty.

16. The reason that a Condorcet proposal exists in this case is that the restriction to symmetric proposals makes the set of alternatives one-dimensional. Under our assumptions on utility functions, they are single-peaked. Hence, the median voter theorem applies, and guarantees the existence of a Condorcet alternative.

17. Less than 5 % of these subjects were economics majors. Most were either pre-business majors or majors in other disciplines in the College of Arts and Sciences.

18. In Phase I, subjects were experienced in the same decision setting but with different parameters. In particular, the subjects in Phase I had all been experienced in a series of experiments investigating behavior in groups with $n=5$.

19. Phase II experiments began with five rounds of decision making to familiarize the subjects with the new benefit function. The decisions in this five-round stage are not examined.

20. There are two additional Phase I experiments that are not reported. These are the first two voting experiments we conducted. In the first of these, there were reasons to believe that some subjects (by means of hand signals and/or whispering) communicated with each other during Stage II. In the second of these, there were reasons to believe that some subjects had communicated between recruitment and beginning of the experiment. Thus, we do not report the results from these experiments because of a loss in experimental control. Following this, we changed recruiting and lab procedures to prevent subsequent loss of control.

21. In pooling the data, we relaxed the conditions on what was referred to as a SYM or a MWC proposal. Specifically, if a proposal had individual token orders that were within plus or minus one of SYM or MWC for any individual, it was counted as SYM or MWC, respectively.

22. The results from these Phase II experiments should be qualified in the following sense. We conjecture that the likelihood of observing MWC proposals and voting is strongly influenced by experience in settings where MWC proposals have been adopted. The Phase II experiments included subjects experienced in Phase I, including the two initial experiments that are not reported (see footnote 20). In each experiment, we made it a point not to limit the number of subjects who had participated in the two initial Phase I experiments. We did, however, include some of these subjects and they would have brought in experience with MWC.

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TABLE 1

Parameterization of Laboratory Experiments

SPECIFICATION	Design Condition	
	Phase I	Phase II
Token Cost Increment (k)	$.01	$.05
Number of Rounds in Each Stage	10	10
Benefit Function ($ax-bx^2$)	a = 0.761 b = 0.007	a = 2.545 b = 0.005
Optimal Strategy	9	7
Symmetric Equilibrium Strategy	14	12
Available Range of Token Orders	[0,80]	[0,80]
Efficiency at Symmetric Equilibrium	69.1%	49.0%
Exchange Rate*	0.25	0.10

* This exchange rate is applied to the computer earnings of each subject to convert these earnings into U.S. currency.

FIGURE 1

Overview of Experimental Design

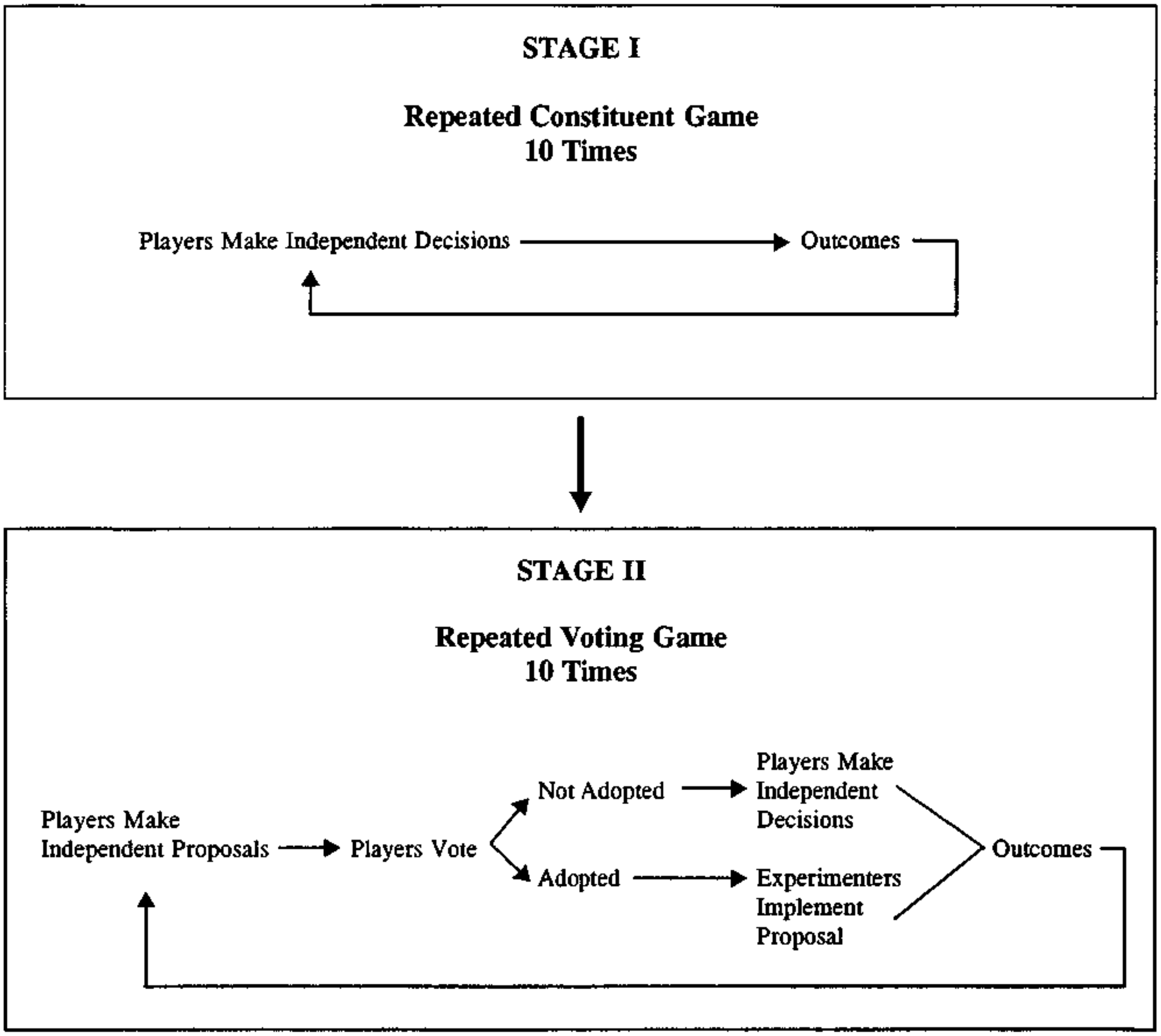


FIGURE 2
Phase I: Simple Majority
Efficiencies

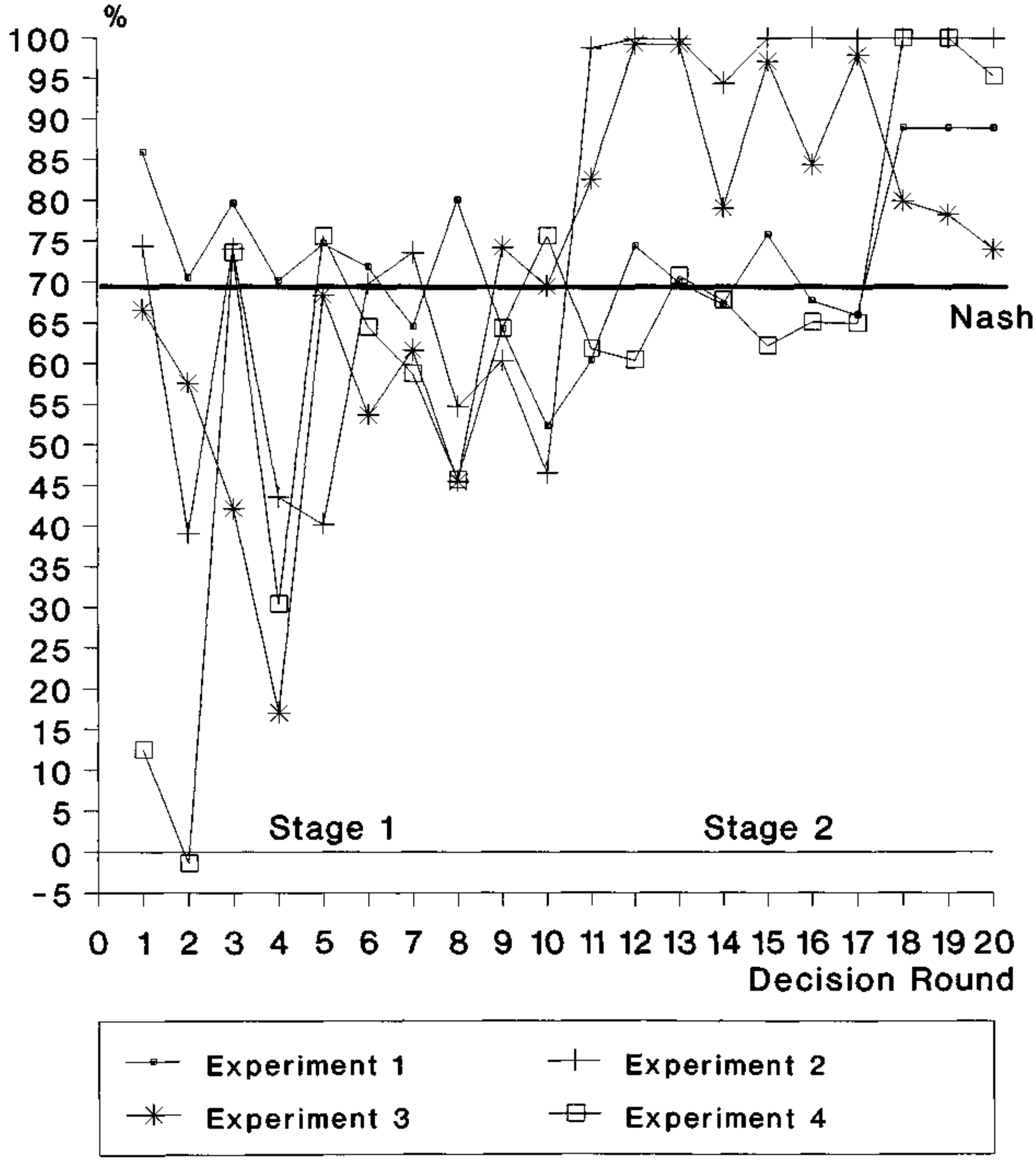


FIGURE 3

SUMMARY OF PHASE I, MAJORITY RULE EXPERIMENTS

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $3.00	18.2%
$3.01-3.50	46.4%
$3.51-4.00	15.4%
$4.01-4.50	6.1%
$4.51-5.00	2.5%
$5.01-5.50	11.4%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $3.00	11.8%
$3.01-3.50	48.9%
$3.51-4.00	17.9%
$4.01-4.50	3.9%
$4.51-5.00	3.9%
$5.01-5.50	13.2%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	0.4%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	3.6%	3.6%	57.1%	7.1%
2	7.1%	7.1%	46.4%	3.6%
3	10.7%	10.7%	57.1%	10.7%
4	10.7%	10.7%	57.1%	21.4%
5	10.7%	10.7%	57.1%	21.4%
6	10.7%	10.7%	57.1%	25.0%
7	10.7%	10.7%	53.6%	28.6%
8	21.4%	14.3%	53.6%	35.7%
9	21.4%	14.3%	60.7%	50.0%
10	28.6%	17.9%	57.1%	42.9%
Total	13.6%	11.1%	55.7%	24.6%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	3.6%	3.6%	60.7%	3.6%
2	7.1%	7.1%	50.0%	17.9%
3	10.7%	10.7%	57.1%	21.4%
4	7.1%	7.1%	50.0%	21.4%
5	14.3%	14.3%	53.6%	28.6%
6	14.3%	14.3%	50.0%	25.0%
7	14.3%	14.3%	53.6%	35.7%
8	28.6%	14.3%	50.0%	50.0%
9	28.6%	17.9%	53.6%	46.4%
10	35.7%	21.4%	53.6%	39.3%
Total	16.4%	12.5%	53.2%	28.9%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	5.4%
50.0-55.0%	0.0%
55.0-60.0%	3.2%
60.0-65.0%	0.4%
65.0-70.0%	1.1%
70.0-75.0%	0.7%
75.0-80.0%	0.0%
80.0-85.0%	6.1%
85.0-90.0%	18.2%
90.0-95.0%	8.6%
95.0-100.0%	56.4%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	2.5%
50.0-55.0%	0.0%
55.0-60.0%	3.2%
60.0-65.0%	0.4%
65.0-70.0%	1.1%
70.0-75.0%	1.1%
75.0-80.0%	0.0%
80.0-85.0%	2.9%
85.0-90.0%	18.6%
90.0-95.0%	10.4%
95.0-100.0%	60.0%

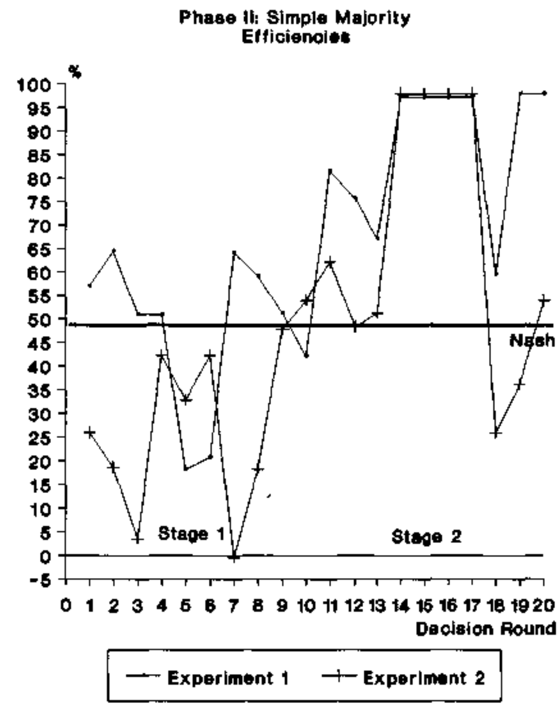
Panel 4P
% of Proposals with Own
Utility >= Nash

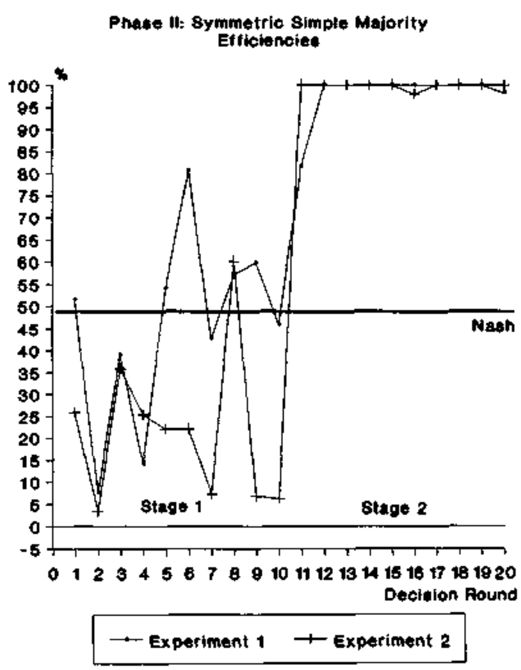
Round	
1	71.4%
2	85.7%
3	85.7%
4	85.7%
5	89.3%
6	89.3%
7	89.3%
8	96.4%
9	100.0%
10	100.0%
Total	89.3%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	78.6%
2	89.3%
3	92.9%
4	89.3%
5	92.9%
6	92.9%
7	96.4%
8	100.0%
9	100.0%
10	100.0%
Total	93.2%

FIGURE 4
Phase II Experiments





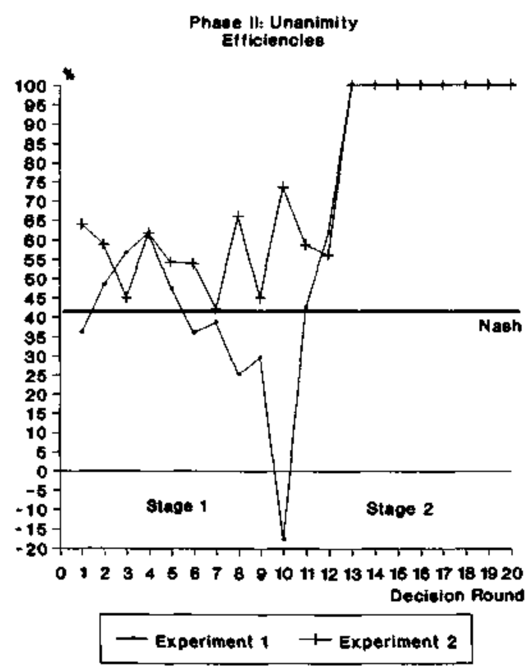


FIGURE 5

SUMMARY OF PHASE II, MAJORITY RULE EXPERIMENTS

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $7.00	10.0%
$7.01-8.50	9.3%
$8.51-10.00	7.9%
$10.01-11.50	1.4%
$11.51-13.00	0.7%
$13.01-14.50	2.1%
$14.51-16.00	65.0%
$16.01-17.50	0.0%
>=17.51	5.7%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $7.00	6.4%
$7.01-8.50	7.1%
$8.51-10.00	10.7%
$10.01-11.50	0.7%
$11.51-13.00	0.7%
$13.01-14.50	2.9%
$14.51-16.00	67.9%
$16.01-17.50	0.0%
>=17.51	3.6%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	35.7%	21.4%	57.1%	0.0%
2	42.9%	21.4%	42.9%	7.1%
3	57.1%	28.6%	28.6%	0.0%
4	64.3%	35.7%	35.7%	7.1%
5	71.4%	42.9%	21.4%	0.0%
6	85.7%	50.0%	7.1%	0.0%
7	71.4%	42.9%	7.1%	0.0%
8	78.6%	50.0%	7.1%	0.0%
9	78.6%	50.0%	7.1%	0.0%
10	85.7%	71.4%	0.0%	0.0%
Total	67.1%	41.4%	21.4%	1.4%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	42.9%	28.6%	57.1%	0.0%
2	50.0%	21.4%	50.0%	14.3%
3	64.3%	21.4%	28.6%	0.0%
4	64.3%	28.6%	35.7%	7.1%
5	71.4%	28.6%	21.4%	0.0%
6	85.7%	42.9%	7.1%	0.0%
7	78.6%	50.0%	0.0%	0.0%
8	85.7%	50.0%	0.0%	0.0%
9	92.9%	50.0%	0.0%	0.0%
10	85.7%	71.4%	0.0%	0.0%
Total	72.1%	39.3%	20.0%	2.1%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	6.4%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.7%
65.0-70.0%	2.9%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	6.4%
85.0-90.0%	4.3%
90.0-95.0%	3.6%
95.0-100.0%	75.7%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	3.6%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	0.7%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	5.7%
85.0-90.0%	3.6%
90.0-95.0%	2.9%
95.0-100.0%	83.6%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	85.7%
2	100.0%
3	92.9%
4	100.0%
5	100.0%
6	92.9%
7	92.9%
8	92.9%
9	92.9%
10	92.9%
Total	94.3%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	92.9%
2	92.9%
3	92.9%
4	92.9%
5	100.0%
6	92.9%
7	92.9%
8	92.9%
9	100.0%
10	92.9%
Total	94.3%

FIGURE 6

SUMMARY OF PHASE II, SYMMETRIC PROPOSAL EXPERIMENTS

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $7.00	2.9%
$7.01-8.50	9.3%
$8.51-10.00	87.9%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $7.00	0.7%
$7.01-8.50	7.9%
$8.51-10.00	91.4%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	21.4%
2	0.0%	0.0%	100.0%	50.0%
3	0.0%	0.0%	100.0%	71.4%
4	0.0%	0.0%	100.0%	85.7%
5	0.0%	0.0%	100.0%	71.4%
6	0.0%	0.0%	100.0%	78.6%
7	0.0%	0.0%	100.0%	85.7%
8	0.0%	0.0%	100.0%	92.9%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%
Total	0.0%	0.0%	100.0%	75.7%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	28.6%
2	0.0%	0.0%	100.0%	71.4%
3	0.0%	0.0%	100.0%	71.4%
4	0.0%	0.0%	100.0%	85.7%
5	0.0%	0.0%	100.0%	78.6%
6	0.0%	0.0%	100.0%	71.4%
7	0.0%	0.0%	100.0%	92.9%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%
Total	0.0%	0.0%	100.0%	80.0%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	1.4%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	1.4%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	4.3%
85.0-90.0%	0.0%
90.0-95.0%	5.0%
95.0-100.0%	87.9%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	0.0%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	0.7%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	2.9%
85.0-90.0%	0.0%
90.0-95.0%	5.0%
95.0-100.0%	91.4%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	92.9%
2	100.0%
3	100.0%
4	100.0%
5	92.9%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%
Total	98.6%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%
Total	100.0%

FIGURE 7

SUMMARY OF PHASE II, UNANIMITY EXPERIMENTS

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $7.00	5.0%
$7.01-8.50	3.6%
$8.51-10.00	91.4%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $7.00	2.1%
$7.01-8.50	2.9%
$8.51-10.00	95.0%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	92.9%	35.7%
2	0.0%	0.0%	92.9%	64.3%
3	0.0%	0.0%	100.0%	85.7%
4	0.0%	0.0%	100.0%	100.0%
5	0.0%	0.0%	100.0%	100.0%
6	0.0%	0.0%	100.0%	100.0%
7	0.0%	0.0%	100.0%	100.0%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%
Total	0.0%	0.0%	98.6%	88.6%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	50.0%
2	0.0%	0.0%	100.0%	85.7%
3	0.0%	0.0%	100.0%	100.0%
4	0.0%	0.0%	100.0%	100.0%
5	0.0%	0.0%	100.0%	100.0%
6	0.0%	0.0%	100.0%	100.0%
7	0.0%	0.0%	100.0%	100.0%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%
Total	0.0%	0.0%	100.0%	93.6%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	2.1%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	2.9%
70.0-75.0%	0.7%
75.0-80.0%	0.0%
80.0-85.0%	2.1%
85.0-90.0%	0.0%
90.0-95.0%	0.7%
95.0-100.0%	91.4%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	0.7%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	1.4%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	2.1%
85.0-90.0%	0.0%
90.0-95.0%	0.7%
95.0-100.0%	95.0%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%
Total	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%
Total	100.0%

APPENDIX A

Signaling and Coalition Formation

The problem of finding coalition partners in a setting where there is no face-to-face communication, and one can only "signal" through the particular proposals that one makes, is a challenging task. If a player wishes to find a grand coalition, then the task is to make a symmetric proposal and to find the symmetric proposal that is close to optimal and gains the initial agreement of at least four players. If one or more players propose the symmetric optimum and it is supported by at least four players, the "problem" of communication for coordination purposes is "solved." If the first symmetric proposal that is agreed upon, however, is not the optimum, the players face the delicate problem of do they move away from what has just won approval to a better proposal. This can be done by at least one person trying to proposal a better symmetric proposal and hoping that the other realizes that this is a better proposal. Since discovering the optimum in this setting is not an immediately obvious task, it is possible for a group to settle into a voting pattern for a symmetric proposal that is not quite at the optimum—as we will see below. Since the experimenter posting the proposals calculated the average token cost of all proposals submitted to a vote, subjects having difficulty determining the impact of a proposal on costs could learn by observing the posted proposal's impact on the cost of tokens.

The problem of finding coalition partners, when one wishes to develop a minimal winning coalition, is even more challenging in this kind of environment. One has to find four individuals who are willing to vote for a MWC if they are part of the MWC and a proposal that these four individuals are willing to support. When the only thing known about the other four players is the information contained in their own proposals and their computer number (without knowing which individual in the room is linked to a computer number), this is a challenging act. One strategy is to propose a MWC using patterns such as including Subjects 1, 2, 3, and 4 (if you are yourself assigned a computer number less than or equal to 4) or Subjects 4, 5, 6 and 7 (if your computer number is greater than 3).

The first experiment in Phase I clearly illustrates the problem of coordinating when some subjects are trying for the grand coalition and some form of symmetric proposal when other subjects are trying to find a set of individuals who will vote for a MWC proposal. In round 1, there were six different proposals. Four of these were more or less symmetric (one at 10 each, one at 13 each, and two at 14 each). One MWC proposal was put forward by Subject 2 involving a proposal of (14,14,14,14,0,0,0). The sixth proposal made by Subject 1 offered Subjects 2 through 7 either 9, 10, or 11 and reserved 18 for Subject 1. The symmetric proposal of all 13s was the only proposal to receive at least two votes.

By round 2, Subjects 2 and 3 had "found one another" in a sea of relatively symmetric proposals. Subject 2 varied his or her earlier MWC[0] to (0,14,14,0,0,14,14), while Subject 3 proposed what Subject 2 had proposed in the earlier round (14,14,14,14,0,0,0) and they both voted for Subject 3's proposal. All the other proposals were variations on a symmetric proposal with the proposal of all 10s receiving two votes.

By round 3, Subjects 1,2, and 3 had found one another but not the identity of a fourth subject who would vote a MWC proposal in with them. They all proposed and voted for (14,14,14,14,0,0,0), while the other four votes were split evenly across a set of symmetric proposals ranging from all 9s to all 15s. Subject 4, who could have voted to be "in" the MWC, instead proposed and voted for the very suboptimal, symmetric distribution of all 15s.

In round 4, there were two "proto coalitions" forming. Three subjects voted for an all 9s proposal. Subjects 1 and 2 stuck with their (14,14,14,14,0,0,0) proposal, while Subject 4 proposed and voted for all 11s. Subject 5 now caught the idea of a MWC and shifted from proposing symmetric distributions to proposing (0,0,0,14,14,14,14). Subject 3 started a signaling strategy that looked like an effort to find someone else to go along with an MWC including the first three subjects. In this round, Subject 3 proposed 40 for Subject 1 and zero for everyone else (including self), but this subject voted for the (14,14,14,14,0,0,0,) proposal.

In round 5, Subjects 1, 2, and 3 were again rejected by Subject 4 in their effort to develop a (14,14,14,14,0,0,0). Subject 3 signaled with a proposal that allocated Subject 2 with 40 and zero to everyone else including self. Subject 5 signaled his or her availability to be in a MWC by proposing (14,14,14,0,14,0,0) but did not gain any supporters. The SYM° of all 9s received two votes and the other two votes went to less efficient, but symmetric, proposals.

Round 6 was quite similar to round 5 with Subject 5 trying to signal a willingness to be in a MWC by proposal (14,14,0,0,14,0,14), while Subjects 1, 2, and 3 voted for their continuing proposal of (14,14,14,14,0,0,0,). Subject 3 now proposed to allocate 40 to self and zeros to everyone else. Round 7 repeated this pattern where Subjects 1, 2, and 3 continued to vote for (14,14,14,14,0,0,0) without attracting Subject 4 to the MWC. This was the round that Subject 3 moved the singular 40 to Subject 4 and zeros to everyone else without attracting Subject 4 to either the MWC or to a "signaling" proposal. Subject 5 continued his or her effort to be included in a MWC by proposal. (14,14,0,14,14,0,0). Subject 4 did not vote for any of the MWC proposals including Subject 4, nor did Subject 4 vote for any proposal during this series other than his or her own proposals, which were always suboptimal and symmetric.

In round 8, Subjects 1, 2, 3, and 5 finally "found one another" and voted in (14,14,14,0,14,0,0) against three votes for an all 9s proposal supported by Subjects 4, 6, and 7. This MWC° held together for the last three rounds.

APPENDIX B

PHASE I, EXPERIMENT 1, SIMPLE MAJORITY RULE

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $3.00	15.7%
$3.01-3.50	37.1%
$3.51-4.00	0.0%
$4.01-4.50	2.9%
$4.51-5.00	0.0%
$5.01-5.50	44.3%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $3.00	10.0%
$3.01-3.50	37.1%
$3.51-4.00	0.0%
$4.01-4.50	1.4%
$4.51-5.00	0.0%
$5.01-5.50	50.0%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	1.4%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	14.3%	14.3%	57.1%	0.0%
2	28.6%	28.6%	57.1%	0.0%
3	42.9%	42.9%	57.1%	14.3%
4	42.9%	42.9%	42.9%	28.6%
5	42.9%	42.9%	42.9%	28.6%
6	42.9%	42.9%	42.9%	28.6%
7	42.9%	42.9%	42.9%	28.6%
8	57.1%	57.1%	42.9%	42.9%
9	57.1%	57.1%	42.9%	42.9%
10	71.4%	71.4%	28.6%	28.6%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	14.3%	14.3%	57.1%	0.0%
2	28.6%	28.6%	71.4%	0.0%
3	42.9%	42.9%	57.1%	28.6%
4	28.6%	28.6%	57.1%	42.9%
5	57.1%	57.1%	42.9%	28.6%
6	57.1%	57.1%	42.9%	28.6%
7	57.1%	57.1%	42.9%	28.6%
8	57.1%	57.1%	42.9%	42.9%
9	71.4%	71.4%	28.6%	28.6%
10	85.7%	85.7%	14.3%	14.3%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	7.1%
50.0-55.0%	0.0%
55.0-60.0%	2.9%
60.0-65.0%	0.0%
65.0-70.0%	2.9%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	2.9%
85.0-90.0%	47.1%
90.0-95.0%	2.9%
95.0-100.0%	34.3%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	2.9%
50.0-55.0%	0.0%
55.0-60.0%	2.9%
60.0-65.0%	0.0%
65.0-70.0%	1.4%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	4.3%
85.0-90.0%	52.9%
90.0-95.0%	1.4%
95.0-100.0%	34.3%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	85.7%
2	85.7%
3	85.7%
4	85.7%
5	85.7%
6	85.7%
7	85.7%
8	100.0%
9	100.0%
10	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	85.7%
2	85.7%
3	85.7%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

PHASE 1, EXPERIMENT 2, SIMPLE MAJORITY RULE

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $3.00	1.4%
$3.01-3.50	85.7%
$3.51-4.00	10.0%
$4.01-4.50	2.9%
$4.51-5.00	0.0%
$5.01-5.50	0.0%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $3.00	1.4%
$3.01-3.50	91.4%
$3.51-4.00	7.1%
$4.01-4.50	0.0%
$4.51-5.00	0.0%
$5.01-5.50	0.0%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	0.0%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	42.9%	0.0%
2	0.0%	0.0%	71.4%	14.3%
3	0.0%	0.0%	100.0%	28.6%
4	0.0%	0.0%	100.0%	42.9%
5	0.0%	0.0%	100.0%	42.9%
6	0.0%	0.0%	100.0%	57.1%
7	0.0%	0.0%	100.0%	71.4%
8	0.0%	0.0%	100.0%	71.4%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	71.4%	0.0%
2	0.0%	0.0%	100.0%	71.4%
3	0.0%	0.0%	100.0%	57.1%
4	0.0%	0.0%	100.0%	42.9%
5	0.0%	0.0%	100.0%	57.1%
6	0.0%	0.0%	100.0%	57.1%
7	0.0%	0.0%	100.0%	85.7%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	0.0%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	1.4%
65.0-70.0%	0.0%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	0.0%
85.0-90.0%	5.7%
90.0-95.0%	2.9%
95.0-100.0%	90.0%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	0.0%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	1.4%
65.0-70.0%	0.0%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	0.0%
85.0-90.0%	2.9%
90.0-95.0%	0.0%
95.0-100.0%	95.7%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	85.7%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	85.7%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

PHASE 1, EXPERIMENT 3, SIMPLE MAJORITY RULE

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $3.00	14.3%
$3.01-3.50	15.7%
$3.51-4.00	41.4%
$4.01-4.50	17.1%
$4.51-5.00	10.0%
$5.01-5.50	1.4%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $3.00	5.7%
$3.01-3.50	8.6%
$3.51-4.00	54.3%
$4.01-4.50	14.3%
$4.51-5.00	14.3%
$5.01-5.50	2.9%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	0.0%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	71.4%	28.6%
2	0.0%	0.0%	28.6%	0.0%
3	0.0%	0.0%	14.3%	0.0%
4	0.0%	0.0%	28.6%	0.0%
5	0.0%	0.0%	28.6%	0.0%
6	0.0%	0.0%	14.3%	0.0%
7	0.0%	0.0%	14.3%	0.0%
8	28.6%	0.0%	14.3%	0.0%
9	28.6%	0.0%	14.3%	0.0%
10	42.9%	0.0%	14.3%	0.0%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	71.4%	14.3%
2	0.0%	0.0%	0.0%	0.0%
3	0.0%	0.0%	0.0%	0.0%
4	0.0%	0.0%	0.0%	0.0%
5	0.0%	0.0%	0.0%	0.0%
6	0.0%	0.0%	0.0%	0.0%
7	0.0%	0.0%	0.0%	0.0%
8	57.1%	0.0%	0.0%	0.0%
9	42.9%	0.0%	0.0%	0.0%
10	57.1%	0.0%	0.0%	0.0%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	2.9%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	1.4%
70.0-75.0%	1.4%
75.0-80.0%	0.0%
80.0-85.0%	8.6%
85.0-90.0%	11.4%
90.0-95.0%	12.9%
95.0-100.0%	61.4%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	0.0%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	2.9%
70.0-75.0%	1.4%
75.0-80.0%	0.0%
80.0-85.0%	1.4%
85.0-90.0%	15.7%
90.0-95.0%	15.7%
95.0-100.0%	62.9%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	71.4%
2	100.0%
3	85.7%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	85.7%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

PHASE 1, EXPERIMENT 4, SIMPLE MAJORITY RULE

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $3.00	41.4%
$3.01-3.50	47.1%
$3.51-4.00	10.0%
$4.01-4.50	1.4%
$4.51-5.00	0.0%
$5.01-5.50	0.0%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $3.00	30.0%
$3.01-3.50	58.6%
$3.51-4.00	10.0%
$4.01-4.50	0.0%
$4.51-5.00	1.4%
$5.01-5.50	0.0%
$5.51-6.00	0.0%
$6.01-6.50	0.0%
> 6.50	0.0%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	57.1%	0.0%
2	0.0%	0.0%	28.6%	0.0%
3	0.0%	0.0%	57.1%	0.0%
4	0.0%	0.0%	57.1%	14.3%
5	0.0%	0.0%	57.1%	14.3%
6	0.0%	0.0%	71.4%	14.3%
7	0.0%	0.0%	57.1%	14.3%
8	0.0%	0.0%	57.1%	28.6%
9	0.0%	0.0%	85.7%	57.1%
10	0.0%	0.0%	85.7%	42.9%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	42.9%	0.0%
2	0.0%	0.0%	28.6%	0.0%
3	0.0%	0.0%	71.4%	0.0%
4	0.0%	0.0%	42.9%	0.0%
5	0.0%	0.0%	71.4%	28.6%
6	0.0%	0.0%	57.1%	14.3%
7	0.0%	0.0%	71.4%	28.6%
8	0.0%	0.0%	57.1%	57.1%
9	0.0%	0.0%	85.7%	57.1%
10	0.0%	0.0%	100.0%	42.9%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	11.4%
50.0-55.0%	0.0%
55.0-60.0%	10.0%
60.0-65.0%	0.0%
65.0-70.0%	0.0%
70.0-75.0%	1.4%
75.0-80.0%	0.0%
80.0-85.0%	12.9%
85.0-90.0%	8.6%
90.0-95.0%	15.7%
95.0-100.0%	40.0%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	7.1%
50.0-55.0%	0.0%
55.0-60.0%	10.0%
60.0-65.0%	0.0%
65.0-70.0%	0.0%
70.0-75.0%	2.9%
75.0-80.0%	0.0%
80.0-85.0%	5.7%
85.0-90.0%	2.9%
90.0-95.0%	24.3%
95.0-100.0%	47.1%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	42.9%
2	57.1%
3	71.4%
4	57.1%
5	71.4%
6	71.4%
7	71.4%
8	85.7%
9	100.0%
10	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	57.1%
2	71.4%
3	85.7%
4	57.1%
5	71.4%
6	71.4%
7	85.7%
8	100.0%
9	100.0%
10	100.0%

PHASE II, EXPERIMENT 1, MAJORITY RULE

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $7.00	15.7%
$7.01-8.50	15.7%
$8.51-10.00	2.9%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	1.4%
$14.51-16.00	58.6%
$16.01-17.50	0.0%
>=17.51	5.7%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $7.00	11.4%
$7.01-8.50	11.4%
$8.51-10.00	4.3%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	2.9%
$14.51-16.00	62.9%
$16.01-17.50	0.0%
>=17.51	7.1%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	28.6%	14.3%	57.1%	0.0%
2	42.9%	14.3%	57.1%	14.3%
3	71.4%	14.3%	28.6%	0.0%
4	57.1%	14.3%	42.9%	14.3%
5	71.4%	14.3%	14.3%	0.0%
6	71.4%	14.3%	14.3%	0.0%
7	57.1%	14.3%	14.3%	0.0%
8	57.1%	28.6%	14.3%	0.0%
9	71.4%	42.9%	14.3%	0.0%
10	71.4%	71.4%	0.0%	0.0%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	28.6%	14.3%	71.4%	0.0%
2	42.9%	14.3%	57.1%	28.6%
3	85.7%	0.0%	14.3%	0.0%
4	71.4%	0.0%	28.6%	14.3%
5	85.7%	0.0%	0.0%	0.0%
6	71.4%	0.0%	14.3%	0.0%
7	57.1%	0.0%	0.0%	0.0%
8	71.4%	28.6%	0.0%	0.0%
9	100.0%	57.1%	0.0%	0.0%
10	71.4%	71.4%	0.0%	0.0%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	11.4%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	4.3%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	10.0%
85.0-90.0%	8.6%
90.0-95.0%	1.4%
95.0-100.0%	64.3%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	7.1%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	1.4%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	8.6%
85.0-90.0%	7.1%
90.0-95.0%	1.4%
95.0-100.0%	74.3%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	85.7%
2	100.0%
3	85.7%
4	100.0%
5	100.0%
6	85.7%
7	85.7%
8	85.7%
9	85.7%
10	85.7%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	85.7%
2	100.0%
3	85.7%
4	85.7%
5	100.0%
6	85.7%
7	85.7%
8	85.7%
9	100.0%
10	85.7%

PHASE II, EXPERIMENT 2, SIMPLE MAJORITY RULE

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $7.00	4.3%
$7.01-8.50	2.9%
$8.51-10.00	12.9%
$10.01-11.50	2.9%
$11.51-13.00	1.4%
$13.01-14.50	2.9%
$14.51-16.00	71.4%
$16.01-17.50	0.0%
>=17.51	5.7%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $7.00	1.4%
$7.01-8.50	2.9%
$8.51-10.00	17.1%
$10.01-11.50	1.4%
$11.51-13.00	1.4%
$13.01-14.50	2.9%
$14.51-16.00	72.9%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 2P.
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	42.9%	28.6%	57.1%	0.0%
2	42.9%	28.6%	28.6%	0.0%
3	42.9%	42.9%	28.6%	0.0%
4	71.4%	57.1%	28.6%	0.0%
5	71.4%	71.4%	28.6%	0.0%
6	100.0%	85.7%	0.0%	0.0%
7	85.7%	71.4%	0.0%	0.0%
8	100.0%	71.4%	0.0%	0.0%
9	85.7%	57.1%	0.0%	0.0%
10	100.0%	71.4%	0.0%	0.0%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	57.1%	42.9%	42.9%	0.0%
2	57.1%	28.6%	42.9%	0.0%
3	42.9%	42.9%	42.9%	0.0%
4	57.1%	57.1%	42.9%	0.0%
5	57.1%	57.1%	42.9%	0.0%
6	100.0%	85.7%	0.0%	0.0%
7	100.0%	100.0%	0.0%	0.0%
8	100.0%	71.4%	0.0%	0.0%
9	85.7%	42.9%	0.0%	0.0%
10	100.0%	71.4%	0.0%	0.0%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	1.4%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	1.4%
65.0-70.0%	1.4%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	2.9%
85.0-90.0%	0.0%
90.0-95.0%	5.7%
95.0-100.0%	87.1%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	0.0%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	0.0%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	2.9%
85.0-90.0%	0.0%
90.0-95.0%	4.3%
95.0-100.0%	92.9%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	85.7%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	100.0%
2	85.7%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

PHASE II, EXPERIMENT 3, SYMMETRIC PROPOSALS

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $7.00	0.0%
$7.01-8.50	17.1%
$8.51-10.00	82.9%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $7.00	0.0%
$7.01-8.50	12.9%
$8.51-10.00	87.1%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	0.0%
2	0.0%	0.0%	100.0%	28.6%
3	0.0%	0.0%	100.0%	71.4%
4	0.0%	0.0%	100.0%	100.0%
5	0.0%	0.0%	100.0%	100.0%
6	0.0%	0.0%	100.0%	100.0%
7	0.0%	0.0%	100.0%	100.0%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	0.0%
2	0.0%	0.0%	100.0%	71.4%
3	0.0%	0.0%	100.0%	71.4%
4	0.0%	0.0%	100.0%	100.0%
5	0.0%	0.0%	100.0%	100.0%
6	0.0%	0.0%	100.0%	100.0%
7	0.0%	0.0%	100.0%	100.0%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	0.0%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	0.0%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	8.6%
85.0-90.0%	0.0%
90.0-95.0%	8.6%
95.0-100.0%	82.9%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	0.0%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	0.0%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	5.7%
85.0-90.0%	0.0%
90.0-95.0%	7.1%
95.0-100.0%	87.1%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

PHASE II, EXPERIMENT 4, SYMMETRIC PROPOSAL

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $7.00	5.7%
$7.01-8.50	1.4%
$8.51-10.00	92.9%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $7.00	1.4%
$7.01-8.50	2.9%
$8.51-10.00	95.7%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	42.9%
2	0.0%	0.0%	100.0%	71.4%
3	0.0%	0.0%	100.0%	71.4%
4	0.0%	0.0%	100.0%	71.4%
5	0.0%	0.0%	100.0%	42.9%
6	0.0%	0.0%	100.0%	57.1%
7	0.0%	0.0%	100.0%	71.4%
8	0.0%	0.0%	100.0%	85.7%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	57.1%
2	0.0%	0.0%	100.0%	71.4%
3	0.0%	0.0%	100.0%	71.4%
4	0.0%	0.0%	100.0%	71.4%
5	0.0%	0.0%	100.0%	57.1%
6	0.0%	0.0%	100.0%	42.9%
7	0.0%	0.0%	100.0%	85.7%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	2.9%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	2.9%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	0.0%
85.0-90.0%	0.0%
90.0-95.0%	1.4%
95.0-100.0%	92.9%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	0.0%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	1.4%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	0.0%
85.0-90.0%	0.0%
90.0-95.0%	2.9%
95.0-100.0%	95.7%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	85.7%
2	100.0%
3	100.0%
4	100.0%
5	85.7%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

PHASE II, EXPERIMENT 5, UNANIMITY

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $7.00	5.7%
$7.01-8.50	5.7%
$8.51-10.00	88.6%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $7.00	1.4%
$7.01-8.50	5.7%
$8.51-10.00	92.9%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	85.7%	14.3%
2	0.0%	0.0%	100.0%	57.1%
3	0.0%	0.0%	100.0%	85.7%
4	0.0%	0.0%	100.0%	100.0%
5	0.0%	0.0%	100.0%	100.0%
6	0.0%	0.0%	100.0%	100.0%
7	0.0%	0.0%	100.0%	100.0%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	28.6%
2	0.0%	0.0%	100.0%	85.7%
3	0.0%	0.0%	100.0%	100.0%
4	0.0%	0.0%	100.0%	100.0%
5	0.0%	0.0%	100.0%	100.0%
6	0.0%	0.0%	100.0%	100.0%
7	0.0%	0.0%	100.0%	100.0%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	2.9%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	2.9%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	4.3%
85.0-90.0%	0.0%
90.0-95.0%	1.4%
95.0-100.0%	88.6%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	1.4%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	0.0%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	4.3%
85.0-90.0%	0.0%
90.0-95.0%	1.4%
95.0-100.0%	92.9%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

PHASE II, EXPERIMENT 6, UNANIMITY

Panel 1P
Histogram of Own
Utility of Proposals

Interval	
<= $7.00	4.3%
$7.01-8.50	1.4%
$8.51-10.00	94.3%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 1V
Histogram of Own
Utility of Votes

Interval	
<= $7.00	2.9%
$7.01-8.50	0.0%
$8.51-10.00	97.1%
$10.01-11.50	0.0%
$11.51-13.00	0.0%
$13.01-14.50	0.0%
$14.51-16.00	0.0%
$16.01-17.50	0.0%
>=17.51	0.0%

Panel 2P
% of Proposals that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	57.1%
2	0.0%	0.0%	85.7%	71.4%
3	0.0%	0.0%	100.0%	85.7%
4	0.0%	0.0%	100.0%	100.0%
5	0.0%	0.0%	100.0%	100.0%
6	0.0%	0.0%	100.0%	100.0%
7	0.0%	0.0%	100.0%	100.0%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 2V
% of Votes that are
MWC, ASYM*, Symmetric, SYM*

Round	MWC	ASYM*	Symm	SYM*
1	0.0%	0.0%	100.0%	71.4%
2	0.0%	0.0%	100.0%	85.7%
3	0.0%	0.0%	100.0%	100.0%
4	0.0%	0.0%	100.0%	100.0%
5	0.0%	0.0%	100.0%	100.0%
6	0.0%	0.0%	100.0%	100.0%
7	0.0%	0.0%	100.0%	100.0%
8	0.0%	0.0%	100.0%	100.0%
9	0.0%	0.0%	100.0%	100.0%
10	0.0%	0.0%	100.0%	100.0%

Panel 3P
Histogram of Efficiency
of Proposals

Interval	
<= 50.0%	1.4%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	2.9%
70.0-75.0%	1.4%
75.0-80.0%	0.0%
80.0-85.0%	0.0%
85.0-90.0%	0.0%
90.0-95.0%	0.0%
95.0-100.0%	94.3%

Panel 3V
Histogram of Efficiency
of Votes

Interval	
<= 50.0%	0.0%
50.0-55.0%	0.0%
55.0-60.0%	0.0%
60.0-65.0%	0.0%
65.0-70.0%	2.9%
70.0-75.0%	0.0%
75.0-80.0%	0.0%
80.0-85.0%	0.0%
85.0-90.0%	0.0%
90.0-95.0%	0.0%
95.0-100.0%	97.1%

Panel 4P
% of Proposals with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%

Panel 4V
% of Votes with Own
Utility >= Nash

Round	
1	100.0%
2	100.0%
3	100.0%
4	100.0%
5	100.0%
6	100.0%
7	100.0%
8	100.0%
9	100.0%
10	100.0%