An Experimental Investigation of Delegation, Voting and the Provision of Public Goods

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Abstract

We explore a possible solution to the free-rider problem involving the delegation of individual contribution decisions to an elected agent. Our first experiment demonstrates that when delegation is an exogenously imposed institution, it results in the efficient full contribution outcome, primarily because groups elect pro-social agents to make the allocation decisions and replace those who do not implement full contribution outcomes. However, we also observe outcomes in which a minimum winning coalition exploits the contributions of the remaining players. Our second experiment demonstrates that when delegation is endogenous, individuals voluntarily cede authority to an elected agent, but only when pre-play communication is permitted. Our combined results demonstrate that delegation can help groups overcome the free-rider problem, even though free-riding incentives still exist under the mechanism.

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Social scientists have long recognized individuals' strong incentives to "free ride" from the contributions of others when public goods are provided through decentralized, voluntary institutions (Lindahl 1919, Samuelson 1954, Olson 1965, Hardin 1968, Dawes 1980). An implication of such individual incentives is that society will tend to under-produce public goods and sometimes even fail to produce them at all.

One justification for government is that it can solve the free-rider problem by using its coercive power—as in Hobbes' *Leviathan*—whereby citizens cede or delegate decision-making to a centralized authority. Indeed, governments provide a variety of public goods ranging from security (national defense, anti-terrorism, police services), to public spaces (libraries and parks), to infrastructure (roads and highways). However, in contrast to Hobbes' ideal vision of an absolute sovereign, central decision-makers in modern democratic governments only wield their power temporarily and subject to popular approval, since regular elections give citizens the opportunity to select new leaders.

We explore the extent to which centralized, delegated decision making can solve the free-rider problem, when the central authority is subject to repeated elections. We conduct two laboratory experiments that investigate the effects of delegation and voting on the provision of public goods. Our first experiment contrasts situations in which individuals independently decide how much to contribute to the public good (i.e., the canonical *voluntary contribution mechanism*) with a *delegation mechanism* in which individuals instead decide who should make allocation decisions for them. Thus, the group delegates authority by electing one of its members to determine the contributions of each member to a public good, including the possibility of asymmetric allocations. This process is repeated in every period.

Our design captures two essential features of modern delegated democracies.[1] First, once elected, a government official is not bound to take any particular action or choose any particular policy. Thus, there is the possibility that an official acts opportunistically for his or her own personal gain (or the gain of a subset of citizens) at the expense of the public at large.[2] Second, an official's power is held only temporarily and continues only if the public collectively chooses to re-elect the official. Thus, repeated elections may provide sufficient incentives for officials to act in the public's interest rather than in their own private interest (Barro 1973; Ferejohn 1986).

We find that such delegation almost always yields outcomes very close to the socially optimal level of the public good, in contrast with the no-delegation, voluntary contributions (VCM), case in which we observe significant levels of free riding. Groups in our experiment typically achieve the socially optimal outcome under delegation by identifying the most "socially-oriented" individuals (who voluntarily contribute the most when delegation is not possible) and granting them the power to determine collective outcomes. When allocators attempt to exploit their position by forcing others to contribute fully while contributing nothing themselves (consistent with the unique equilibrium of the one-period game), they are almost always removed from office in the next period. Thus, elections help to produce socially desirable outcomes through both selection and sanctioning of allocators.

However, we also observe instances in which the elected allocator appeals to a majority of players in the game and exploits the contributions of the remaining minority of players. This "majority tyranny" outcome yields greater inequality than when none of the public good is provided at all, and also leaves those excluded from the majority with lower earnings than they would likely obtain without delegation. Thus, while our results generally support the beneficial effects of delegation on social welfare, they also highlight an important trade-off: majority tyranny might arise

[1] We use the term "delegated democracy" to include both delegation to a single individual or executive as well as to a legislative body in order to distinguish it from "representative democracy," which typically refers to the latter. In contrast, a "direct democracy" involves citizens proposing and voting directly on proposals and does not involve any form of delegation.
[2] See McGuire and Olson (1996) and Falaschetti and Miller (2001) for related theoretical analyses.

when decisions are delegated to a centralized authority, but it cannot when individuals retain complete liberty over their contribution decisions.

Our first experiment demonstrates how delegation solves the free rider problem despite the potential for opportunistic gain by elected agents, but the experiment exogenously imposes a centralized decision-making institution. In our second experiment, we turn to the question of whether individuals will voluntarily cede the right to make individual decisions, allowing centralized decision making to arise endogenously. This is an important question because the voluntary decision to submit to a centralized political institution may itself be subject to a second-order free rider problem. We introduce an *endogenous delegation mechanism* in which subjects first choose to opt in or opt out of centralized decision-making in each period.[3] Those who opt-in elect an allocator and are bound by the allocator's decision while those who opt-out make their own individual contribution decisions. Rules regarding the production of the public good remain the same so that players opting out of the delegation mechanism benefit from any public good provided by the allocator's decision and vice versa.

We find that when players cannot communicate prior to making decisions in the endogenous delegation mechanism, few agree to delegate and contributions converge to zero just as in the VCM. However, when pre-play discussion is possible, half of the groups voluntarily opt for the delegation mechanism and sustain outcomes close to full efficiency. Communication appears to work in conjunction with endogenous delegation because it provides a means for coordination and fosters trust, which encourages individuals to cede the right to make independent decisions to an elected allocator. While we also find that communication encourages higher levels of initial contributions under the VCM without delegation, it is not nearly as effective at producing or sustaining full contributions as when delegation is possible.

[3] See Kosfeld, Okada, and Riedl (2009) for another example of endogenous centralization, but in the context of a sanctioning institution rather than an electoral institution.

Related Literature

There is a vast experimental literature on the provision of public goods by voluntary contributions (e.g., Andreoni 1988; Dawes et al 1986; Ostrom et al 1992; Fehr and Gächter 2000),[4] but there are very few public goods experiments that involve voting or delegation. Walker et al (2000) conducted an experiment in which subjects propose and vote directly on proposals to extract resources from a common pool and find that binding votes (both majority rule and unanimity) significantly increase the efficiency of resource use. Similarly, Kroll, Cherry, and Shogren (2007) find that in a linear, symmetric public goods environment like ours binding votes and non-binding votes with punishment both increase contributions to the public good (but non-binding votes without punishment do not). Unlike our experiment, however, these two studies involve direct democracy rather than delegation—individuals propose and vote directly on contribution levels.[5] Although direct democracy can solve the coordination problem involved with collective action, there is no opportunity for an elected leader to unilaterally gain at the expense of other group members. That is, unlike in our setting, there is no principal-agent problem or problem of accountability as in many real-world political institutions involving delegation.

Experiments by social psychologists Messick and Samuelson are perhaps most closely related (Messick et al 1983; Samuelson et al 1984; Samuelson and Messick 1986). In their experiments, subjects play several periods of a simulated common pool resource game—there is no actual group since other players' actions are actually pre-determined by the experimenter, who provides false feedback—and then vote on whether to maintain free access to the resource (analogous to voluntary contributions in the public goods setting) or to elect a leader to make binding future decisions. They find that subjects are much more likely to give up free access to the resource

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[4] For reviews, see Ledyard (1995) and Ostrom (1998, 2000).

[5] Capra et al (2007) also find that voting (direct democracy) increases social efficiency relative to decentralized decision-making in a more complicated economic environment with a threshold externality. Theoretical work on voting mechanisms has also focused on direct democracy rather than delegation (Ledyard 2006).

and to delegate to an elected leader when the resource is (inefficiently) overused under a voluntary institution. This suggests that individuals will sometimes voluntarily cede control of decision-making to a centralized authority. In Messick et al (1983), subjects are also told that they have been "elected" as the leader, and they tend to take advantage of their position by personally taking more of the resource than they assign to other members of the group.

A critical difference between our experiments and Messick and Samuelson's is that their experiments provide false feedback to subjects, who never actually interact with each other. [6] Their use of fictitious "groups" means that we cannot know from their experiments how social interaction and group dynamics affect outcomes under the delegation mechanism. Moreover, elections play no role in their setup as groups do not have real opportunities to elect leaders and leaders never face the prospect of re-election or removal from office. It is therefore not surprising that their subjects act selfishly and take more for themselves as leaders, although it is surprising that they don't take *all* of the resource. In contrast, the results of our experiments indicate that voting, elections, and communication are all important forms of social interaction that help to overcome the free rider problem and suggest that group dynamics and collective choices are just as important as individual decisions.

Theoretical Framework

The setting for our experiments is a series of repeated decisions in a group context, under a linear public goods production framework. There are n members of a group, and interactions between members of the same group are repeated with a potentially infinite horizon.

[6] The use of deception is generally frowned upon in experiments in economics and game theory, because it may negatively affect the experimenter's control of the social situation and subjects' expectations and judgments, making the internal validity of such experiments questionable (Ortmann and Hertwig 2002).

Stage Game

In each period, every individual member of an n-person group has an endowment w, which is to be divided between spending on a private good and contributions to a public good. Let x_i be the amount that individual i allocates to the public good (subject to the restriction that $0 \le x_i \le w$), with the remainder of the endowment $w - x_i$ allocated to the private good. The amount of the public good provided is the sum of group members' contributions, $\sum_{j=1}^{n} x_j$. Individual i's payoff is the sum of benefits from the private and public goods, where the marginal benefit from the private good is 1 and the *marginal per capita benefit* from the public good is k/n. This payoff is given by the expression

$$(w - x_i) + \frac{k}{n}\sum_{j=1}^{n} x_j \ .$$

We assume that $1 < k < n$, which ensures the presence of a collective action problem: social welfare is maximized when every individual contributes their full endowment to the public good but under voluntary contributions it is always individually rational to contribute nothing for any amount contributed by others.

Alternative institutional rules determine how decisions to allocate spending between private and public goods are made in each period. The baseline institution is the *voluntary contribution mechanism* (VCM) in which every individual group member simultaneously and independently chooses his or her own contribution x_i to the public good. In the unique Nash equilibrium of the one-shot game, all players contribute zero to the public good and receive payoffs equal to their endowment (w). Previous experimental studies of voluntary contributions involving repetition generally find that contributions start between 40 and 60 percent of the endowment and converge toward the zero-contributions Nash equilibrium (e.g., Isaac, Walker, and Thomas 1984; Isaac, McCue, and Plott 1985; Andreoni 1988; Fehr and Gachter 2000).

Our main alternative collective choice institution involves *delegation by plurality rule* in which decision-making is divided into two stages in every period. First, group members simultaneously cast votes for any member of the group. The group member with the most votes is elected as the “allocator” for the current period (with ties broken randomly). In the second stage, the designated allocator chooses a vector of contributions to the public good—that is, the allocator separately chooses an individual amount x_i for each of the n members of the group. The allocator’s choices are binding. The stage game under this institution has a unique subgame perfect equilibrium: whoever is the allocator makes all others contribute and contributes nothing herself. Anticipating this, in the first stage all players vote for themselves. Ex post and ex ante payoffs for this outcome are given in Table 1.[7] In this equilibrium, elected allocators obtain the highest possible *ex post* payoffs but the election of allocators is determined randomly.

Repeated Play

After every period there is some probability $\delta \in (0,1]$ that the interaction will continue for another period. Since our decision setting involves repetition between members of the same group and an infinite horizon, a folk theorem argument implies the existence of a multiplicity of equilibria in which each member receives at least the minmax payoff.

Under the voluntary contributions mechanism, the minmax payoff is w, which results when a player keeps all her endowment and no other players contribute to the public good. This is also the unique Nash equilibrium outcome of the stage game and therefore can be supported as an equilibrium of the indefinitely repeated game. Our parameterization of the game also permits the full contribution outcome as an equilibrium outcome of the repeated game.[8]

[7] Table 1 also presents the payoffs for the other outcomes described below in both general form and given the specific parameterization described later.
[8] Calculations for all repeated-game equilibria based on experimental parameters are available from the authors.

Under the delegation institution, the minmax payoff for any player *i* is *kw/n*, which is obtained when *i* is fully exploited by the other members of the group. That is, all other members vote for some allocator other than *i* and the allocator decides that only *i* contributes to the public good while allowing every other player to free ride off of *i*'s contribution. Thus, the delegation mechanism allows the implementation of a minmax payoff that is *worse* than the minmax payoff of *w* under voluntary contributions. Our parameterization of the game again supports full contributions as a repeated-game equilibrium under delegation.

Of course, there are also many other equilibrium outcomes of the repeated game. Given the multiplicity of equilibria, we hypothesize that three kinds of outcomes will be focal when decision making is delegated. One such outcome is that individuals will play the subgame-perfect equilibrium of the stage game in which all players vote for themselves and the randomly-determined winner of the election contributes nothing to the public good while making all *n*–1 other members contribute their full endowment.

The second type of outcome is also based on pure self-interest but takes the nature of voting into account. It is best characterized by the phrase "tyranny of the majority." Our expectations are based on long-standing normative concerns about majority rule (e.g., *Federalist No. 10*) and by relatively more recent theoretical results concerning minimum winning coalition sizes (Riker 1962; McKelvey, Ordeshook, and Winer 1978). In this outcome, a simple majority of group members vote for the same allocator in the first stage, thus forming a winning coalition. The selected allocator then selects a contribution vector such that non-members are forced to contribute fully to the public good and the group members contribute nothing, effectively free riding off of the minority. Majority and minority payoffs are summarized in Table 1. Even if the excluded members are able to coordinate on a single candidate, they will be unable to obtain a plurality and change the first-stage election outcome. If the marginal per capita return is low enough, then the same allocator will be elected in each period by members of the majority coalition, whose payoffs are higher than they would be under the socially optimal outcome.[9]

The third type of outcome involves delegation producing the socially efficient outcome of full contributions ($x_i = w$ for all i). This occurs when the elected allocator ensures that the full amount of each member's endowment goes toward the public good. This outcome is consistent with evidence from experiments that individuals may be motivated by efficiency, equality and social welfare rather than pure self-interest (Fehr and Schmidt 1999; Charness and Rabin 2002).

Experiment 1: Voting and Delegation

Our first experiment involves a direct comparison of the voluntary contributions mechanism with delegation by plurality rule. We also include, for each mechanism, communication conditions in which individuals can engage in pre-play messaging at the beginning of each period, resulting in a 2 x 2 factorial design.

We include the communication treatments for two reasons. First, we are interested in comparing the extent to which communication can enhance efficiency under voluntary contributions and under delegation. Since communication prior to voting or selecting contributions is "cheap talk," it does not change the incentive structure of the game. Nevertheless, previous studies found that pre-play communication can increase the rate of voluntary contributions (e.g., Dawes, McTavish, and Shaklee 1977; Isaac and Walker 1988a), but such improvement does not always occur and can depend on characteristics of the public goods games such as payoffs (Wilson and Sell, 1997; Isaac and Walker 1988b). Since the specific payoffs we use in our experiment yield a low marginal per capita return from the public good, this strong incentive to free ride may counteract the beneficial effects of communication in the voluntary mechanism. However, we also suspect that

[9] It is not absolutely necessary for members to elect the same allocator in every period as long as the majority coordinates their votes for the allocator, which allows for a variant in which members of the majority rotate in office.

communication may make it easier to coordinate on a candidate in elections under the delegation mechanism or to coordinate on one of the focal outcomes.

Second, the communication treatment also provides us with insight into how players make their decisions in the voting state of the delegation treatment. For example, if we were to observe the "majority tyranny" outcome, the transcripts of the pre-play communication might allow us to directly observe the coalition formation.

Experimental Design

Our experiments were conducted at the Pittsburgh Experimental Economics Laboratory (PEEL). Subjects interacted through networked computers using an application written with the software *z-tree* (Fischbacher 2007).[10] Subjects were primarily undergraduate and graduate students at the University of Pittsburgh and Carnegie Mellon University and were recruited through an e-mail list. Earnings in the game were denominated in "tokens," and total earnings were converted to cash at the rate of $1 for every 200 tokens. In addition, each subject received a $5 show-up fee. The experiment did not involve any kind of deception.

An experimental session consisted of two groups of nine subjects (n = 9). Once groups were assigned, they remained fixed for the duration of the session. In every period, each individual was given an endowment of w = 100 tokens ($0.50). We used the parameter k = 1.35 so the marginal per capita return (MPCR) from the public good was k/n = 0.15 tokens. This parameterization guarantees that it is socially optimal (in terms of aggregate welfare) for every member to contribute to the public good (earning 135 tokens, or $0.68) but that it is individually rational to never contribute (free riding when everyone else contributes fully earns the maximum 220 tokens, or $1.10, while contributing fully when no one else does earns the minimum 15 tokens, or $0.08). We also emphasize that our

[10] The full text of the instructions is available from the authors.

MPCR is lower than in many previous studies and therefore provides a very strong incentive to free ride.[11]

Ex post and ex ante stage game payoffs from the focal outcomes of the delegation mechanism discussed above, given our parameterization of the game, are shown in the third column of Table 1. Note that in the delegation treatments every member of a simple majority coalition is better off from “majority tyranny” than the full contribution outcome. In addition, both the delegation stage game subgame perfect equilibrium and majority tyranny outcomes are ex ante preferred to the VCM Nash equilibrium of full free riding.

To induce a potentially infinite horizon while ensuring that subjects interacted for a sufficiently long time, each group played a minimum of 20 periods (divided into two parts, as described below) and after the 20th and any subsequent period there was a 0.75 probability of continuing the game for another period.[12]

Upon arriving in the laboratory, each subject was seated at a computer station, randomly assigned an ID number and to one of the two groups. All interactions took place through the networked computers and members of each group could only identify other group members by their ID number.[13] In every session, subjects were first informed that they were placed in a group with nine members, that the experiment was divided into two parts, and that each part consisted of a series of “periods.”

Part 1 of the experiment was identical across all treatment conditions and consisted of five periods of the baseline voluntary contribution mechanism without communication (described below). This allowed subjects to become familiar with the structure of payoffs and to experience the free rider problem. It also allows us to obtain a measure of each subject’s pro-social orientation in terms

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[11] Previous research finds that decreasing the MPCR leads to lower contribution rates (Isaac and Walker, 1988; Isaac, Walker and Williams, 1994). These studies find contribution rates of around 20% for MPCR values of 0.3 in repeated public goods games.

[12] Our discount rate can be thought of as being $\delta = 1$ for the first 20 periods and $\delta = 0.75$ thereafter.

[13] Having two groups play simultaneously further helped to preserve anonymity.

of his or her willingness to contribute to the public good under the voluntary contribution mechanism.

Subjects received instructions about the public goods game, the payoffs in each period, and were informed that Part 1 would last for five periods. The instructions did not make any reference to "public" or "private" goods but instead to "Account A" (the private good) and "Account B" (the public good). After every period, each subject observed the results of that period, including the individual allocations made by each group member, the total amount contributed to the public good, and the subject's own earnings from the period. Subjects knew that there would be a Part 2, but received no information about it prior to completing Part 1.

When Part 1 concluded, subjects received instructions for Part 2, which varied according to the institutional features of the treatment conditions. In every condition, however, subjects were informed that they would be playing at least 15 additional periods and that after the 15^{th} period (20^{th} overall) and any subsequent period there would be a 75 percent chance of continuing for another period.

In the baseline control condition (*voluntary contributions without communication*), subjects continued to play the same game as in Part 1. We conducted this treatment to serve as a comparison with the other institutions and to ensure that the "restart" after the 5^{th} period would not substantively affect the results.

In the *delegation without communication* treatment, rather than individually choosing how to divide the endowment between the private and public good, at the beginning of every period each subject voted for one of the nine group members to be the "allocator" for that period. Subjects voted by clicking on one of nine buttons on their screens, corresponding to group members' ID numbers. When voting, subjects were informed about the average individual-level voluntary public good contributions for each group member in Part 1 of the experiment (periods 1 through 5). That is, subjects could see how cooperatively each person in their group behaved during the voluntary contributions periods in Part 1. After voting, the numbers of votes received by each member (but not the identities of the voters) were shown to all subjects, and the group member with the most votes was elected the allocator. If more than one member received the most number of votes, then one person was selected at random from this set. The allocator then decided how many tokens each group member would allocate to the public good, by entering a contribution in each of nine boxes corresponding to one group member. The allocator was allowed to select different levels for each individual. All group members then observed the allocator's decision prior to beginning the next period.

Two additional treatments allowed subjects the opportunity to communicate prior to every period in Part 2. In the *voluntary contributions with communication* treatment, subjects participated in up to 90 seconds of electronic written communication prior to making voluntary contribution decisions in each period. The method of communication was through an electronic "chat" program (i.e., "instant message") embedded in the software. Messages identified only the ID number of the sender, and in each session, subjects could only see messages sent by members of their own nine-member group. Subjects could enter any kind of text message as long as it did not allow anyone else to identify them personally (e.g., age, race, or appearance) and as long as they avoided using obscene, offensive, or inappropriate language.

The *delegation with communication* treatment added a similar pre-play chat feature to the delegation institution. That is, prior to voting in each period, subjects participated in up to 90 seconds of electronic written communication with the same rules as above.

Results

We conducted 12 sessions involving 216 subjects who were divided into a total of 24 groups. There were two sessions of the baseline *voluntary contributions without communication* condition (4 groups, labeled B1-B4), two sessions of *voluntary contributions with communication* (4 groups, labeled C1-C4), four sessions of *delegation without communication* (8 groups, labeled D1-D8), and four sessions of *delegation with communication* (8 groups, labeled DC1-DC8). Each subject participated in a single session of the experiment.

Aggregate Outcomes and Allocations

Figure 1 presents the average group allocation to the public good over time (for the 20 guaranteed periods) by treatment. The results from Part 1 of the experiment (periods 1-5), in which every group plays the voluntary contribution game without communication, are consistent with findings in the literature. The average contribution in each condition began around 45 percent of the endowment and steadily declined to around 15 percent in period 5 with no substantive differences between conditions.

In Part 2 of the baseline condition, where subjects continued to play the VCM without communication as in Part 1, average contributions declined even further—to about 1 percent—by period 20, the last guaranteed period. This gives us confidence that our parameter values provide strong incentives for free riding, as behavior converges towards the stage game Nash equilibrium of zero contributions.

We find that both delegation and communication significantly increase public goods contributions to levels close to the social optimum, at least initially. In period 6, average contributions in each (non-baseline) treatment range from 84 to 93 percent of the endowment, and of the 20 groups in these three conditions 14 achieve the social optimum of full contributions. However, the high level of contributions to the public good in the voluntary plus communication treatment is unsustainable, as contributions fall to about 13 percent by period 20. In contrast, the high level of contributions to the public good is sustained throughout the guaranteed periods in both delegation treatments, with the treatment average always remaining above 85 percent.

Our observations are supported by the statistical analysis of group-level outcomes presented in Table 2. We estimated a regression model (column 1) that included dummy variables for each treatment condition, a time trend (number of Part 2 periods played), interactions between treatments and time, and group random effects. The dependent variable is the proportion of the total endowment contributed to the public good.

Model 1 supports our observation that both delegation and communication significantly increase the initial levels of the public good provided, but that there is also no statistical difference between the different treatments. The analysis also supports our observation that contributions in the delegation treatments remain steady over time while there is a significant decrease in contributions when subjects communicate without centralized decision-making. These results also hold when we control for between-group differences measured by the average contributions from Part 1 (model 2).

Heterogeneity Across Groups

Figure 2 shows the amount allocated to the public good over time by each group in Experiment 1. The results are striking. Of the delegation groups (including delegation with communication), D1 and DC2 achieve the socially optimal level (full contributions) in *every* period of Part 2 of the experiment. Six more groups achieve it in all but one or two periods. Five more groups achieve it in at least a majority of periods, and only one group (D2) fails to achieve the socially optimal outcome at all. The delegation results stand in stark contrast to the results of the voluntary plus communication treatment in which the social optimum is achieved in at most five periods (by group C2, with C3 achieving it three times and C4 achieving it twice) and to the baseline condition in which it is never achieved at all.

To provide a clearer picture in terms of the observed allocation vectors in Part 2 of the delegation treatments, we classify them into several categories and present the frequencies of different categories in Table 3. The first three categories represent our hypothesized outcomes under delegation. We code an allocation as a *full* contribution vector (FULL) if the maximum amount of the public good is provided. This category accounts for 72.8 percent of all allocations. A *stage game* outcome (SG) is one in which the allocator's contribution is 0 while the other players' contributions are each 100. There are ten groups that have at least one SG outcome, but this accounts for only 6.9 percent of all allocations. A *minimum winning coalition* outcome (MWC) is one where the allocator assigns five members (including him or herself) to contribute nothing while making four other group members contribute fully. There are only two groups with at least one MWC allocation, which accounts for 3.4 percent of all allocations. Overall, these three categories account for 83.1 percent of all observed allocations, with full contributions clearly accounting for the bulk of them and the other categories accounting for small but non-trivial shares. In addition, FULL and SG outcomes account for 100 percent of all allocations for four groups while they account for over 90 percent of outcomes for six additional groups.

We also coded two additional categories that represent qualitatively similar, but weaker, versions of the stage game and minimum winning coalition outcomes. The category SG+ includes outcomes in the SG category as well as allocation vectors in which the allocator (uniquely) contributes the smallest amount to the public good. In other words, the SG+ category represents any allocation in which the elected allocator uses his or her power to earn more than any other player in the group. Overall, this kind of selfish behavior on the part of the allocator describes 12.2 percent of allocations.

The category MWC+ describes allocations that can be characterized as involving some form of majority tyranny where a minority is made to contribute higher amounts to the public good than the majority. More specifically, the MWC+ category includes allocations in the MWC category as well as any outcome in which the allocator chooses to make four or fewer members (not including him or herself) contribute the highest amount to the public good.[14] In our experiment, the majority tyrannizes the minority 8.4 percent of the time.

Table 3 also reveals that the two groups in which the modal outcome was not the socially optimal outcome (FULL) tend to exhibit high degrees of selfish allocation behavior. Of the allocations for group D2 (which never achieves the social optimum, as noted above) 34.8 percent are classified as SG outcomes and 13 percent are classified as MWC. When the weaker definitions are applied, the amount of behavior characterized as selfish increases substantially (69.8 percent SG+, 60.9 percent MWC+). In fact, only one outcome for this group does not fall into either the SG+ or MWC+ categories.

Outcomes for group DC1, which has the second fewest full contribution outcomes, fall primarily in the majority tyranny categories (42.1 percent MWC and 52.6 MWC+). Interestingly, Figure 2 shows that this group starts at or near full contributions in period 6 but then drops to the MWC amount in period 12. The chat transcript shows that prior to the drop in allocations to the public good, the elected allocator explicitly proposes to tyrannize the minority by implementing the MWC allocation: "I HAVE AN IDEA…It would turn us against each other though…I have 5 ppl give 0…and 4 give 100 and screw them…hahaha…and I would always be leader because the vote is 5-4." Four other participants agreed to go along with the proposed plan, resulting in several periods of the precise majority-tyranny outcome that we hypothesized.[15]

Thus, it appears the delegation mechanism generally yields a very high frequency of socially optimal outcomes. Even though the allocator has an incentive to force others to contribute while contributing nothing, this outcome (SG) arises infrequently. However, in two groups that most frequently fail to achieve the socially optimal outcome we observe regular occurrences of both the individually self-interested (SG) outcome and the majority tyranny (MWC) outcome.

[14] Note that according to our definitions, the SG+ and MWC+ outcomes are not mutually exclusive.
[15] Interestingly, the coalition temporarily fell apart when the allocator, angered at not having received a vote of allegiance from one coalition member, attempted to punish this subject by forcing him or her to contribute.

Allocator Behavior, Selection, and Sanctioning

To better understand why most groups achieve the socially optimal outcome under delegation while some exhibit selfish or apparently irrational behavior, we focus on the two aspects of electoral accountability emphasized by Fearon (1999): selection and sanctioning. More specifically, in the delegation treatments, do groups "select good types"—allocators who choose full contributions? And if they do not, are they able to "sanction poor performance" by replacing poorly performing allocators with new ones?

First, we show that different "types" of allocators do in fact behave differently. Within groups, we ranked members by their average contribution in Part 1 of the experiment, when contributions were voluntary, and then categorized subjects into three types: the highest ranked contributor within each group, the lowest ranked contributor, and everyone else (i.e., middle-ranked).[16] Table 4 summarizes the behavior of elected allocators by type. The upper panel shows the mean and standard deviation of the aggregate per period amount each type allocated to the public good when selected as allocator. The highest ranked contributors (i.e., subjects who voluntarily gave the most in Part 1) produced the most contributions to the public good on average as allocators (96.8% of the total endowment)—very close to the socially optimal level—while middle-ranked contributors were close behind (94.8%). The difference between these two groups is not statistically significant. In contrast, when low Part 1 contributors were in the role of allocator, they allocated 25% *less* than the middle-ranked types, and the difference is statistically significant. When we also control for groups' average Part 1 contribution levels, time trends, and allow for group random effects in our regression analysis (column 3 of Table 2), we find that the difference between high and middle types is statistically significant as well as the difference between middle and low types. Overall, the data suggests that "selecting good types" means "*avoiding* bad types" (i.e., the lowest Part 1 contributor).

[16] If the rank ordering of contributions is strict, then there is one high contributor, one low contributor, and seven middle-ranked contributors. The exact number of subjects within each category may vary if there are ties for highest or lowest contributors.

The lower panel of Table 4 summarizes the characteristics of the allocation vectors chosen by each type of allocator (using the categories from Table 3). This provides additional evidence that the behavior of low Part 1 contributors, in the role of allocator, is systematically more self-interested than the behavior of other group members. Again, the types of allocations chosen by high and middle contributors appear to be very similar: full contribution vectors account for 78.4 and 84.6 percent of decisions made by high and middle contributors, respectively. But low contributors are the least likely to implement the socially optimal allocation: only 16.7 percent of their allocations fall in the full contribution category while 40.5 percent are characterized by some form of majority tyranny (i.e., MWC+) and in 52.4 percent of their allocations they obtain higher benefits at the expense of their entire group (i.e, SG+).

Is there any evidence in terms of voting behavior that subjects attempt to select good types, or at least avoid bad ones? Table 5 summarizes the voting decisions and election results from period 6, the initial period of Part 2. The data suggest that subjects use available information but also that competing factors might influence this decision. Consistent with predicted stage game equilibrium behavior, 42 percent of subjects voted for themselves—a substantial but not overwhelming amount. The second most common factor was voting for the high contributor (36 percent of votes cast). This resulted in the election of the high contributor in 10 out of the 16 groups. Thus, more than half of the groups selected the high contributor and were able to avoid the low contributor. Combined with the benefits from selecting the high contributor evident in Table 4, this indicates why delegation was effective: groups delegated to high contributors and these subjects in turn overwhelmingly implemented full contributions.

Table 5 also reveals, however, that some subjects cast votes for either the low contributor or for the subject with the lowest ID number in their group. The latter could have been due to a ballot-order effect—that is, some subjects might have simply voted for the subject who is listed as the first option on their voting screen.[17] A look at the raw data suggests that low contributors may be elected due to the ballot-order effect.[18] Indeed, the only two low contributors who are actually elected as allocators also happen to be first on their ballots (groups D2 and DC1).

But even if a group is "unlucky" enough to select the low contributor, repeated elections provide a natural mechanism for rewarding good allocator behavior with re-election while sanctioning poor performance by "throwing the bums out."[19] Across delegation treatments with and without communication, when allocators implement the full contribution vector they are retained in office in the next period at a very high rate (93.3 percent). When allocators attempt to secure re-election by providing benefits to a majority coalition (either MWC or MWC+), they also do rather well: the re-election rates are 60 percent for MWC allocations and 76.9 percent for MWC+. Thus, allocators who provide benefits to the entire group or to a majority of voters are retained in office. But consistent with the use of repeated elections as a corrective device, allocators who implement the stage game (SG) equilibrium outcome are the least likely to be re-elected: overall, they are re-elected in only 30 percent of subsequent periods and are *never re-elected* by 6 of the 9 groups in which the SG vector is observed.

Overall, despite occasional instances of selfish behavior and majority tyranny, the simple electoral institution in our experiment works because it allows groups to both select good types (by

[17] In the voting screen, subject ID numbers are listed in ascending order with the low ID listed at the top of the voting buttons. We estimated a conditional logit model to assess whether there was any statistical difference between voting for the low contributor and voting for the low ID number and found that while each effect is statistically significant, they are indistinguishable from each other.

[18] When we exclude subjects who voted for themselves, there are only 3 votes (2.1 percent) for candidates who are the low contributor but do not have the low ID number, suggesting that subjects only very rarely vote for the low contributor when it is not themselves or the first candidate on the screen. However, there are 13 votes (9 percent) for candidates with low ID numbers who are not the low contributor and 7 votes (4.9 percent) for candidates with low ID numbers who are also the low contributor.

[19] In theory, repeated elections might induce "good behavior" even by "bad types" if the allocator fears being punished by another allocator or being excluded from a majority coalition in future periods. Without conducting additional experiments, however, we cannot know the full extent to which allocators are influenced by such considerations. But the data in Table 2 suggests future electoral considerations are insufficient to deter low contributors from selecting stage game outcomes.

avoiding low contributors) and sanction poor performance (by replacing allocators who behave selfishly and without the support of a majority of their group).

Experiment 2: Endogenous Delegation

The results of Experiment 1 clearly show the social welfare maximizing effects of delegation. An important question is whether individuals and groups will voluntarily forego their ability to make their own choices in favor of delegation. In Experiment 2, we allow group members to individually decide whether to make their own decision or cede their agency to an elected allocator. Group membership (and an individual's access to the public good) is unaffected by this choice; regardless of individuals' choices, they remain in the same group of nine for the entire experiment and receive payoffs from the public contributions of others. Therefore, this experiment explores behavior in an *endogenous delegation* condition, in which subjects in each period decide whether to make individual contribution decisions or to participate in the delegation mechanism. As in Experiment 1, we also explore the effects of communication and therefore include an *endogenous delegation with communication* condition.

In Experiment 1, the delegation mechanism proved effective at overcoming the free rider problem because it allows contribution decisions to be centrally made by socially-oriented allocators. However, the endogenous decision to cede agency to such a mechanism creates a second-order free-rider problem. Each individual player has a dominant strategy in the stage game to refuse to delegate and then to contribute nothing, resulting in the lack of public goods just like in the voluntary contributions mechanism.

Experimental Design

Experiment 2 uses the same nine-person group repeated game environment as Experiment 1. The key difference is that, at the beginning of a period, each subject decides whether to "opt in" or "opt out" of the delegation mechanism. By opting in a subject voluntarily agrees to allow a subsequently-determined elected allocator to make the contribution decision on his or her behalf, while opting out means that a subject will personally make his or her own allocation decision. If zero or one group members opt in the game is identical to the baseline voluntary contributions game in Experiment 1 (all subjects make their own contribution decisions), while if all group members choose to elect an allocator the game is identical to the delegation condition from Experiment 1 (one subject makes all contribution decisions). In the intermediate cases, those who opt in to the mechanism elect an allocator from amongst themselves and are bound by the allocator's decisions, while those who opt out of the mechanism make allocation decisions independently as in the baseline.

As in Experiment 1, sessions consisted of two parts. In Part 1, each group played five periods of the public goods game with voluntary contributions. In Part 2, subjects participated in the endogenous delegation treatment, with 20 guaranteed periods and a subsequent 0.75 continuation probability. In sessions with communication, group members communicated using the same technology as in Experiment 1. We conducted three sessions (six groups) for each of the *endogenous delegation* and *endogenous delegation with communication* treatments.

Results

Figure 3 presents the contributions to the public good and the number of group members who chose to opt in, across all periods for each group. The six panels on the left show the results from endogenous delegation without communication groups (E1-E6) while the panels on the right show the results when allowing communication (EC1-EC6). Without communication, the ability to endogenously choose delegation fails to improve contributions to the public good, and the aggregate patterns bear a close resemblance to the those of the baseline groups (without communication). The average contribution levels are very low, and over time the Part 2 contributions converge toward zero for every group.

Allowing communication prior to the "opt in" decision appears to have a significant positive effect, albeit with some heterogeneity. Four of the six groups achieve full contributions at least once. Three groups (EC2, EC3, EC6) sustain full contributions in a majority of periods—similar to the behavior of groups in the delegation conditions of Experiment 1. In other groups, especially EC1 and EC4, high levels of contributions are unsustaintable—similar to groups in the voluntary contributions with communication condition of Experiment 1. Our observations are supported by the regression analysis of group-level contributions in Table 6, which compares the endogenous delegation groups with the baseline groups from Experiment 1 (similar to the analysis presented in Table 2) allowing for group random effects (columns 1 and 2) and also controlling for group heterogeneity (column 2).

The results indicate an interactive effect between endogenous centralization and communication. Endogenous centralization reintroduces a sufficiently strong incentive to free ride such that without communication, the level of contributions quickly collapses to the inefficient subgame-perfect Nash equilibrium outcome, but when communication is allowed the free rider problem is overcome at least part of the time. The interaction effect is also evident in Figure 4, which shows the frequency with which groups achieve full contributions by institution and by the availability of pre-play communication. Communication clearly has a stronger effect under endogenous centralization than in the other treatments.

The results of Experiment 2 also suggest that opt-in behavior is strongly and positively correlated with the level of the public good provided. Those groups attaining the highest delegation rates achieve the highest public good contributions. This is evident in Figure 5, which plots the average endowment contributed to the public good for each group against the average number of members opting in during the guaranteed periods of Part 2 (6-20). It is also evident in column 3 of Table 6, which adds the percentage of the group that opts in as an additional explanatory variable to the regression analysis. The opt-in variable is substantively large, statistically significant, and reduces the direct effect of the endogenous delegation with communication treatment by a substantial margin. This provides additional evidence that the high levels of public good provision in EC groups is due to an interaction between endogenous delegation and communication rather than communication per se.

To quantify the effects of communication on opt in decisions in the EC groups we estimated several probit models, which are presented in Table 7. The dependent variable is whether a subject opted for delegation in a period. The effects of communication on initial opt-in decisions are presented in columns 1 (which controls for individual Part 1 contributions) and 2 (which controls for both individual and group Part 1 contributions). The results show that subjects who voluntarily gave more in Part 1 are more likely to opt-in during the first period of Part 2, but the effect of communication is, at best, weak: the estimate is not significant in column 1 and is significant at the .10 level when controlling for group averages in column 2.

When the analysis is extended to all periods, however, the effects of communication are quite strong. Not only does communication significantly increase the overall probability of opting in, but the analysis shows that with communication, subjects' willingness to opt in *increases* over time.[20] This effect can also be seen in Figure 3 for group EC2 (which begins Part 2 with only one member opting in and quickly ends up with 8 to 9 members opting in within the next 3 periods) and EC6 (which begins with 7 opting in and subsequently sustains all members opting in until period 20). Thus, when communication is combined with endogenous delegation, the joint effect is to not merely sustain contributions but to encourage them.

Examining the chat transcripts provides some insights about the way in which communication fosters opting in behavior and high contribution levels. In five of the six groups, subjects discuss a unanimity rule or contingency strategy along the following lines: if everyone opts

[20] For both columns 3 and 4, the sum of the time trend and time-communication interaction is positive and statistically significant.

in, the allocator should use every member's full endowment for the public good but if at least one member opts out, the allocator should put nothing in the public good. If subjects expect that elected allocators will actually follow this rule, it reduces the risk of contributing and serves as a sort of "money back guarantee" along the lines of Dawes et al (1986). This appears to be the basis for the successful provision of public goods in groups EC2 and EC6. Interestingly, group EC3 achieves full contributions without full delegation: at most 7 members opt in, but while the remaining two members never delegate they nevertheless contribute fully to the public good.

In contrast, in groups where contributions are not sustained at high levels (EC1, EC4 and EC5), the willingness to delegate is persistently lower because at least one member always free rides. But even though EC1 did not achieve full contributions, the transcript suggests that allocators did, in fact, use the "money back" strategy. In period 10, after only 5 members opted in, the allocator says "too many people quit…I had to choose 0 for all of us." In period 15, 8 members opt in and the allocator puts all of their endowment toward the public good, realizing that everyone would be better off even though one group member continued to opt out and free ride. This success is short-lived, however, because fairness considerations begin to enter into the discussions ("yeah but i hate that one person gets to get more then everyone"). In subsequent periods, only 7 members opt in, and the allocator returns to the all-or-nothing strategy.[21]

Simple content analysis of the chat transcripts also provides additional insight. We first code every line of text in terms of whether it is *relevant* to the game (involves payoffs, strategies, or behavior). The amount of relevant communication is inversely related to the level of public good provided and to the number of members opting in (the correlations are -0.20 and -0.22, respectively, and both are statistically significant at the 5 percent level). Relevant communication is typically intense in early periods for groups that successfully provide the public good and then dies out once

[21] Note that group members would still have been better off when 7 members opted in had the allocator implemented full contributions among those opting in (resulting in a payoff of 105 tokens) than the full free riding outcome (100 tokens).

the group settles on the full contribution outcome. Conversely, in groups that fail to reach full allocations, relevant communication continues throughout the session as subjects struggle to convince others to opt in. Interestingly, even though communication is an important factor that contributes to delegation outcomes, successful groups only require a little bit of it, early on, in order to succeed.

We also code whether messages are *individualistic* (involve the words "I", "me", or "mine") and whether they are *collectivist* (involve the words "we", "us", "group", "all", "our", or "everyone"). Opt in behavior and the successful provision of public goods are positively related to the proportion of relevant speech that is collectivist rather than individualistic (the correlations are 0.27 and 0.29 and both are statistically significant). Thus, it appears that groups are successful when communication promotes group cohesion and discussions of collective, rather than individual, interest.

Experiment 2 demonstrates that at least some groups are able to achieve high levels of public good provision by voluntarily ceding the right to select contribution levels to an elected agent.[22] However, a majority of groups, including all of those operating without pre-play communication, fail to obtain the potential benefits from delegation. We see communication work successfully in Experiment 2 because it facilitates group members' decisions to opt for delegation. Thus, communication allows groups to achieve high stable contribution rates; but, rather than doing so by increasing contribution rates directly, it instead appears effective primarily because it produces high rates of opting in to the delegation mechanism.

[22] The voting behavior in the EC groups fail to offer the same clear insight as Experiment 1, where electing the highest and lowest contributing group members from Part 1 have strong differential effects on group contributions. Over the first five periods of Part 2, the high contributor from Part 1 is never elected, and only once does a group member elect the low contributor; the low contributor in EC4 refuses to contribute until the group agrees to elect him or her as the allocator in period 10. Group discussion leads group members to agree on their allocator, resulting in nearly homogenous voting behavior within groups.

Conclusion

We explore the idea that centralization can effectively solve the free rider problem. In our experiments, authority is delegated to a centralized decision maker through repeated elections. Thus, allocators are subject to popular approval and hold power only until the next election. We find that a democratic version of the Hobbesian solution to the free rider problem indeed works to achieve socially efficient outcomes, although the institution is not entirely without limitations.

Theoretically, our institutional environment has three potential drawbacks. One is a principal-agent problem in which the elected agent gains at the expense of the rest of the group. We find that this problem is mitigated when delegation is combined with repeated elections (as it is in modern real-world institutions) because voters avoid selecting allocators who are likely to use their authority opportunistically. When allocators do attempt to free ride off of the rest of the group, they are promptly replaced.

Another potential problem is majority tyranny, whereby a majority of the group free rides off the contributions of a minority. This outcome is clearly inequitable but yields higher payoffs to those in the majority than under full contributions. We observe this outcome in our experiment when groups happen to select a selfish allocator (due to ballot-order effects) but subsequently fail to replace the selfish type with a more socially-oriented type.

A third drawback of delegation pertains not to the features of the institution itself, but instead to the problem of attaining centralized institutions in the first place. If individuals are free to choose individually whether or not to delegate authority to an elected leader, a second-order free rider problem arises and in theory decentralization should be pervasive. We find that the second-order collective action problem seriously limits the provision of public goods when individuals cannot communicate. But allowing communication encourages higher levels of delegation and, in turn, increases the level of public good provided. Importantly, we find that the effects of delegation combined with communication are greater than the effects of communication alone, which validates the role of delegation as a key institutional feature.

Although much of the existing literature on institutions and collective action problems has appropriately focused on institutional features relevant to self-governance such as communication and enforcement (Ostrom, Walker, and Gardner 1992; Dickson, Gordon, and Huber 2009), it is also important to understand how features of real-world democratic institutions shape the provision of public goods. We take an important step in that direction by demonstrating that democratic delegation can be extremely effective at solving the free rider problem and providing public goods, but our results also raise several interesting questions for future research.

First, what are the effects of other political structures? We explored a relatively simple political institution involving delegation to a single decision-maker. What if representation were more fragmented, such as delegation to a legislative body? Or what if the voting rule were plurality rule with a run-off instead of simple plurality?

Second, why are socially efficient outcomes more prevalent than majority tyranny? One reason may be that majority tyranny requires a majority of group members to be narrowly self-interested in order to sustain a minimum winning coalition and shut out the minority, and perhaps enough subjects are either concerned with fairness or social efficiency that this condition is not met. This possibility can be tested by systematically assigning high and low voluntary contributors to different groups rather than using random assignment. Another reason may be the homogeneity of agents in our public goods environment.[23] Would inequitable outcomes be more likely if endowments or marginal benefits were distributed unequally, or even if we introduced a “minimal groups” paradigm? Finally, it may be that the allocators in our environment do not have sufficient incentives or opportunities to pursue the majority tyranny strategy. This could be addressed by

[23] Alesina, Baqir, and Easterly (1999) find that public goods provision is inversely related to ethnic fragmentation at the local level in the United States.

providing additional benefits from holding office or by allowing group members to communicate privately with other individuals rather than publicly.

Third, what explains the joint effect of endogenous delegation and communication? We have demonstrated that the joint effect is causal and communication is more effective at sustaining the level of centralization than individual contributions. We have also shown that groups that successfully provide public goods need only a small amount of relevant communication, which tends to be collectivist rather than individualistic in nature. However, we do not yet have a fully developed theory of why the two institutional features work together. This limitation is not unique to our own analysis (e.g., see Buchan, Johnson, and Croson 2006 with respect to the effects of communication in a trust game). Similarly, although delegation in other contexts removes the pressure to behave fairly (Hamman, Loewenstein, and Weber 2009), in our context delegation seems instead to reduce the temptation to act opportunistically.

Overall, our experiment has shown that delegation can be quite beneficial. We expect that future research will clarify more precisely the conditions under which political institutions produce socially efficient levels of public goods.

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Table 1. Individual stage game payoffs from focal outcomes

Outcome and role	General expression	Implemented tokens
Full contributions – every member	kw	135
Voluntary stage game Nash – every member	w	100
Delegation stage game SPE – ex post allocator	$\left(1+\frac{k(n-1)}{n}\right)w$	220
Delegation stage game SPE – ex post non-allocator	$\frac{k(n-1)}{n}w$	120
Delegation stage game SPE – ex ante	$\frac{1+k(n-1)}{n}w$	131.1
Majority tyranny – ex post majority	$\left(1+\frac{k(n-1)}{2n}\right)w$	160
Majority tyranny – ex post minority	$\frac{k(n-1)}{2n}w$	60

Table 2. Random effects regression analysis of group contributions in Experiment 1

	All conditions		Delegation conditions only
	(1)	(2)	(3)
Communication	0.532***	0.525***	
	(0.152)	(0.168)	
Delegation	0.501***	0.498***	
	(0.117)	(0.122)	
Delegation with communication	0.533***	0.530***	0.056
	(0.117)	(0.123)	(0.041)
Period (Part 2)	-0.011***	-0.011***	0.003
	(0.002)	(0.002)	(0.002)
Communication x Period	-0.041***	-0.041***	
	(0.004)	(0.004)	
Delegation x Period	0.013***	0.013***	
	(0.003)	(0.003)	
Delegation with communication x Period	0.010***	0.010***	-0.003
	(0.003)	(0.003)	(0.003)
Part 1 average contribution in group		0.044	0.172
		(0.376)	(0.108)
Allocator high Part 1 contributor			0.047*
			(0.026)
Allocator low Part 1 contributor			-0.081**
			(0.033)
Constant	0.405***	0.394***	0.823***
	(0.068)	(0.116)	(0.048)
σ_{μ}^2	0.263	0.268	0.044
σ_{ε}^2	0.154	0.154	0.126
R^2 within	0.281	0.281	0.006
R^2 between	0.592	0.591	0.520
R^2 overall	0.571	0.571	0.214
N	690	690	320

* p < .10, ** p < .05, *** p < .01, random effects at the group level.

Table 3. Percentage of observed allocations in delegation groups

	Hypothesized Allocations				Other Allocations		
Group	FULL	SG	MWC	Total Hypothesized	SG+	MWC+	Periods
D1	100	0	0	100	0	0	23
D2	0	34.8	13.0	47.8	69.8	60.9	23
D3	66.7	11.1	0	77.8	33.3	0	18
D4	88.9	5.6	0	94.5	5.6	5.6	18
D5	60.9	8.7	0	69.6	26.1	0	23
D6	95.7	4.4	0	100	4.4	0	23
D7	55.6	0	0	55.6	5.6	0	18
D8	77.8	16.7	0	94.5	16.7	0	18
DC1	26.3	0	42.1	68.4	0	52.6	19
DC2	100	0	0	100	0	0	19
DC3	42.9	4.8	0	47.6	4.8	4.8	21
DC4	95.2	0	0	95.2	0	4.8	21
DC5	94.1	5.9	0	100	5.9	0	17
DC6	82.4	11.8	0	94.1	11.8	0	17
DC7	90.5	4.8	0	95.2	4.8	0	21
DC8	95.2	0	0	95.2	0	0	21
All D	67.7	10.4	1.8	79.9	20.7	9.2	164
All DC	78.2	3.2	5.1	86.6	3.2	7.7	156
Total	72.8	6.9	3.4	83.1	12.2	8.4	320

Note: SG+ and MWC+ are not mutually exclusive.

Table 4. Elected allocator decisions by initial contribution rank

	Allocator Part 1 Contribution Rank		
	Highest	Middle	Lowest
Contributions (% of endowment)			
Mean	96.8	94.8	69.8
S.D.	10.7	16.2	27.0
Allocation types (% of decisions)			
FULL	78.4	84.6	16.7
SG	2.0	6.9	23.8
MWC	0	3.1	16.7
SG+	5.4	6.9	52.4
MWC+	1.4	6.2	40.5
N	148	130	42

Note: Percentages are within column; SG+ and MWC+ are not mutually exclusive. The highest and lowest categories refer to individual subjects who gave the most or least in their group.

Table 5. Initial voting in delegation groups

	Percentage of votes	Average number of votes received	Number elected
Self	41.7		
High contributor	36.1	3.1	10
Low contributor	13.9	1.0	2
Low subject ID	18.1	1.6	4
N	144	144	16

Note: Only high contributor and low contributor are mutually exclusive categories.

Table 6. Random effects regression analysis of group contributions in Experiment 2 compared to baseline conditions in Experiment 1

	(1)	(2)	(3)
Communication	0.822***	0.973***	0.917***
	(0.157)	(0.126)	(0.120)
Endogenous	0.075	0.044	-0.144
	(0.143)	(0.102)	(0.099)
Endogenous with communication	0.740***	0.777***	0.259**
	(0.143)	(0.103)	(0.112)
Period	-0.005**	-0.005**	-0.005**
	(0.002)	(0.002)	(0.002)
Communication x Period	-0.046***	-0.046***	-0.046***
	(0.005)	(0.005)	(0.004)
Endogenous x Period	-0.007*	-0.007*	0.001
	(0.004)	(0.004)	(0.004)
Endogenous with communication X Period	-0.015***	-0.015***	-0.020***
	(0.004)	(0.004)	(0.004)
Part 1 average contribution		-0.851***	-0.532*
		(0.325)	(0.312)
Percent of group opting in			0.767***
			(0.081)
Constant	0.115	0.325***	0.247**
	(0.110)	(0.112)	(0.107)
σ_{μ}^2	0.211	0.14	0.135
σ_{ε}^2	0.172	0.172	0.155
R^2 within	0.383	0.383	0.504
R^2 between	0.738	0.808	0.862
R^2 overall	0.637	0.679	0.756
N	370	370	370

* p < .10, ** p < .05, *** p < .01; random effects at the group level.

Table 7. Probit and random effects probit analysis of opt-in decisions

	Initial period		All periods	
	(1)	(2)	(3)	(4)
Communication	0.391	0.489*	1.533***	1.921***
	(0.250)	(0.267)	(0.341)	(0.345)
Individual average Part 1 contribution	1.246*	1.721**	0.878	2.667***
	(0.667)	(0.791)	(0.833)	(0.933)
Group average Part 1 contributions		-0.002		-0.007***
		(0.002)		(0.002)
Period			-0.072***	-0.072***
			(0.012)	(0.012)
Communication x Period			0.110***	0.109***
			(0.018)	(0.018)
Constant	-0.656***	-0.407	-1.129***	-0.147
	(0.233)	(0.319)	(0.298)	(0.375)
σ_{μ}^{2}			1.47	1.359
			(0.149)	(0.139)
log likelihood	-70.53	-69.881	-635.723	-629.112
N	108	108	1854	1854

* p < .10, ** p < .05, *** p < .01; individual level random effects included in (3) and (4)

Figure 1. Average group contributions to the public good in Experiment 1

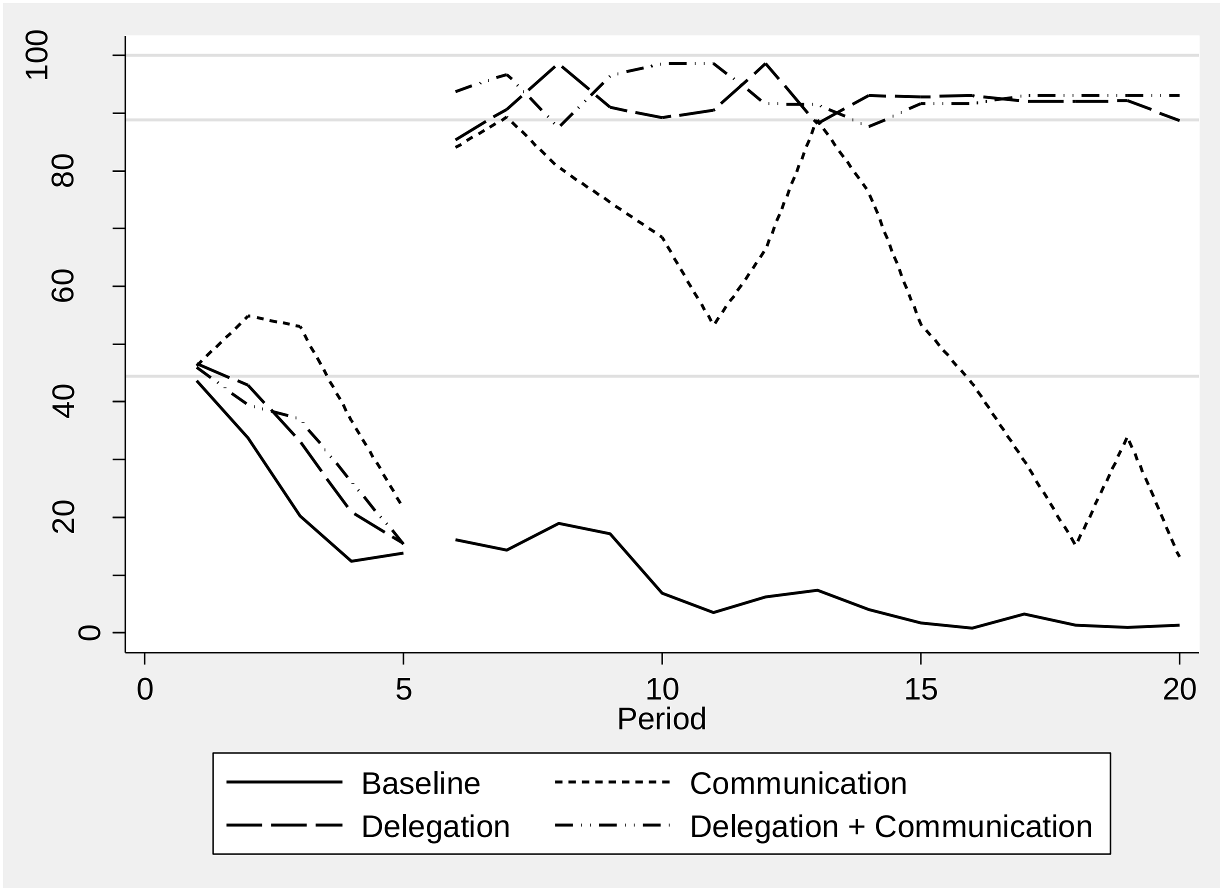

Figure 2. Group contributions to the public good over time in Experiment 1

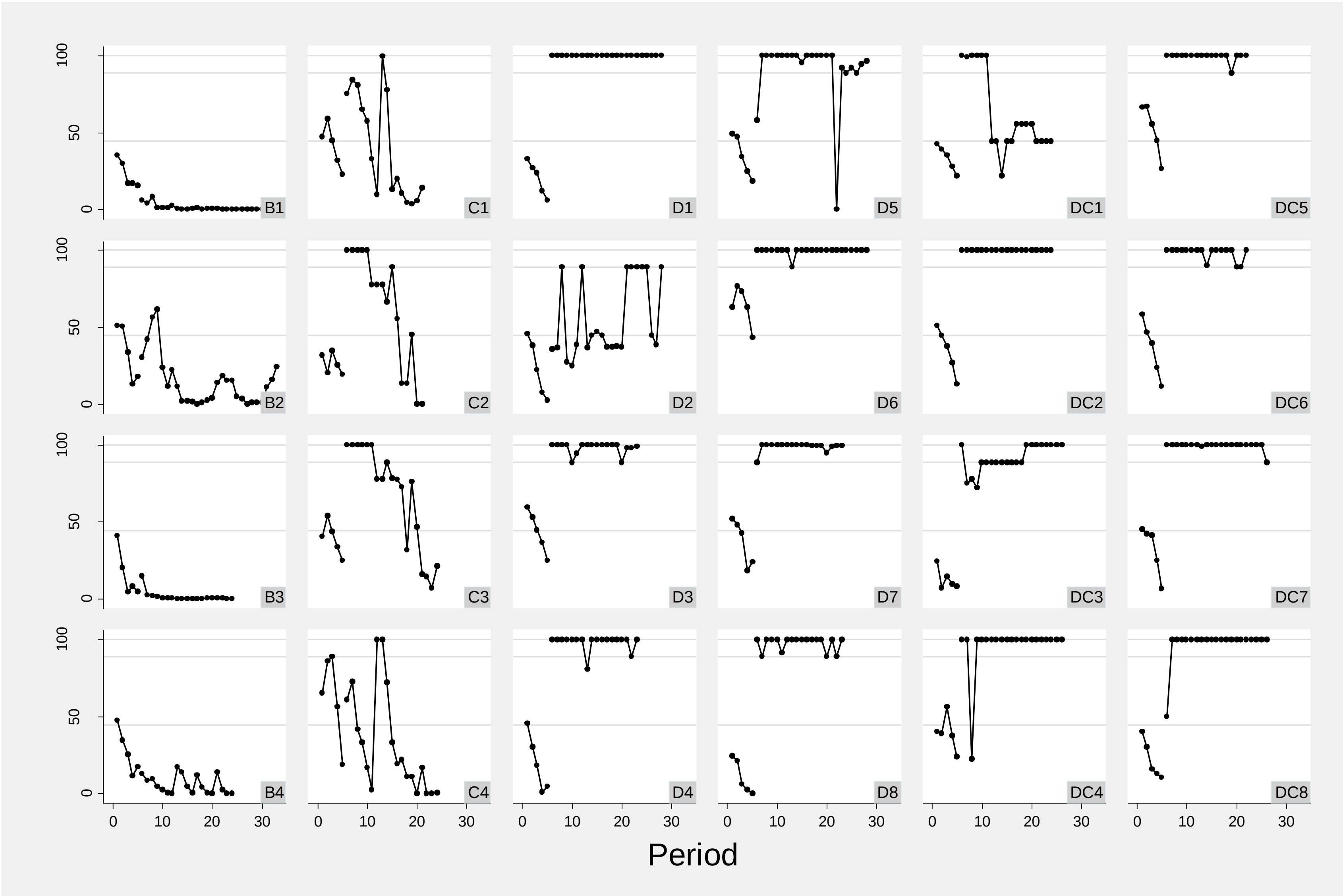

Figure 3. Public good contributions and opt-in decisions over time in Experiment 2

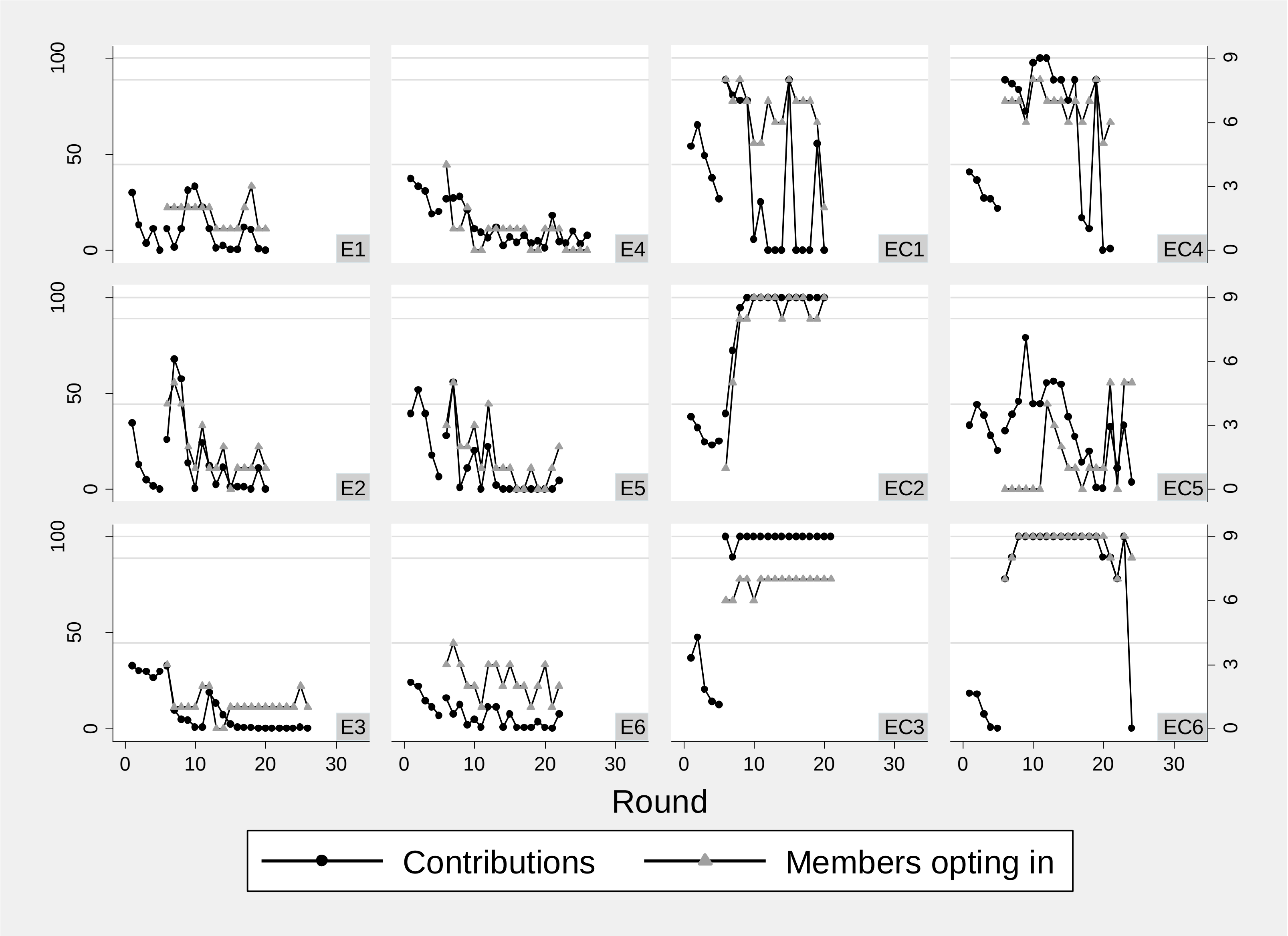

Figure 4. Frequency of socially optimal outcomes by treatment (periods 6-20)

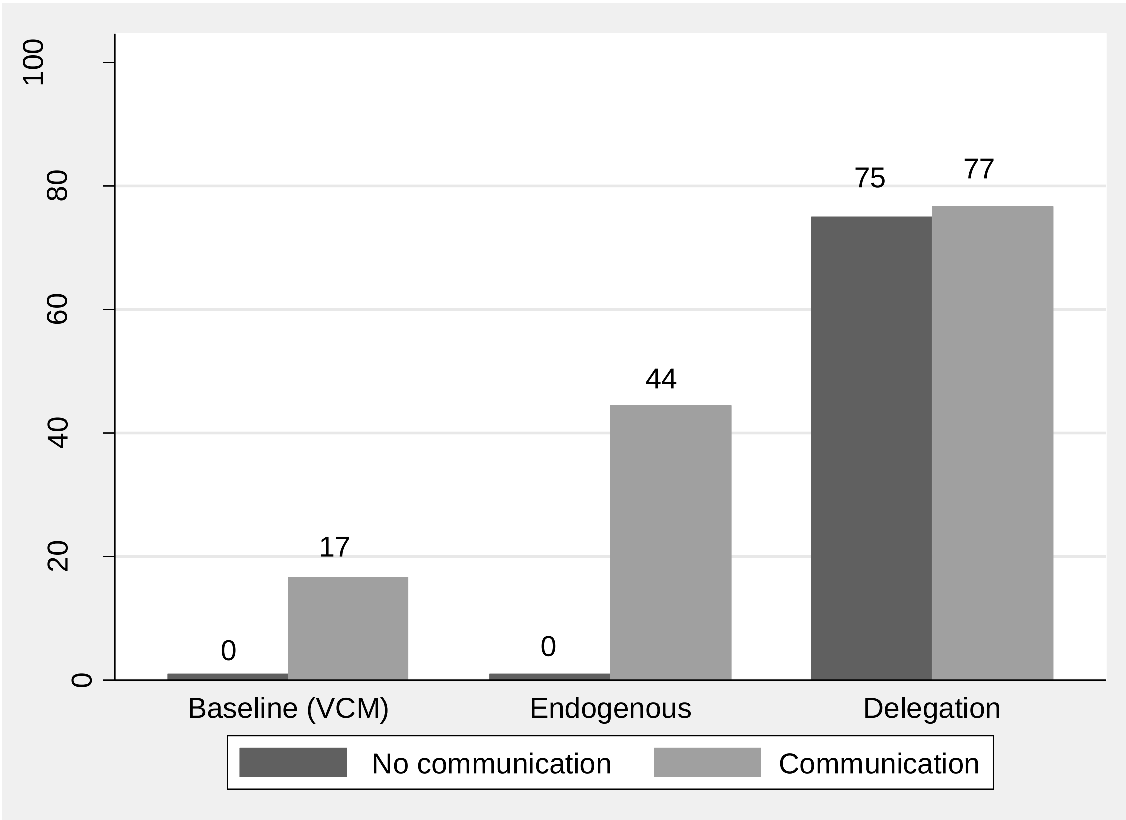

Figure 5. Group opt-in and contribution levels in Experiment 2 (periods 6-20)