Public Goods Provision with Voting for Exclusion, Exit, and Mergers: An Experiment

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Abstract: We test a mechanism whereby groups are formed endogenously, through the use of voting. These groups play a public-goods game, where efficiency increases with group size (up to a limit, in one treatment). Information is provided about the contributions of others and it is feasible to exclude group members, exit one's group, or to form larger groups through mergers involving the consent of both merging groups. We find a great degree of success for this mechanism, as the average contribution rate is very high. The driving force appears to be the economies of scale combined with the awareness that bad behavior will result in (potentially-reversible) exclusion. However, it is possible for an excluded person to be later again become part of an efficient large group. This "redemption" is not a rare occurrence, with about one-fifth of the population becoming good citizens after initially being low contributors.

Keywords: Endogenous group formation, Exclusion, Experiment, Merger, Public goods, Redemption, Social efficiency, Voting

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1. Introduction

While achieving cooperation is beneficial or even critical for groups or societies, doing so may be problematic since individual incentives often conflict with socially-efficient actions. Even if people feel inclined to help out, they may lose the taste for cooperating when they see other people not doing their share. The issue of how to successfully implement collective action when there is a prospect of such free riding is a vital topic in public economics.

Experiments have investigated the provision of public goods since at least Marwell and Ames (1979). The basic idea is that each person has an endowment to allocate between private goods and public goods, with a contribution to the public good creating more social surplus than a contribution to the private good. However, each individual only receives a fraction of the amount contributed, so that it is rational to allocate one's endowment to private goods. Standard public-goods games typically find moderate initial contributions declining steadily over time. How can long-term efficiency be sustained? One approach involves identification of individual contributions and voluntary punishment. While some studies (e.g., Fehr and Gächter 2000) show that the level of cooperation can be sustained fairly well, punishment is inefficient, as it involves sacrifice to lower the payoff of another person.[1] Punishment may also undermine altruistic cooperation.[2] An alternative approach is to allow the group in question to evolve endogenously, as with *assortative matching*.[3] Tiebout (1956) argued that efficient provision is feasible if groups were allowed to self-sort, implying a basic mobility to the society.

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[1] Masclet, Noussair, Tucker, and Villeval (2003) find that while non-monetary (and so not inefficient) punishments are as effective as monetary punishments in initially increasing contributions, they are less effective over time.
[2] See, for example, Fehr and Rockenbach (2003) and Fehr, Klein, and Schmidt (2007).
[3] Sober and Wilson (1998), Frank (1988), and Bergstrom (2002) show that cooperative behavior can survive if it entails advantages over selfish behavior; these advantages can include an improved chance of being matched with like-minded individuals and a better chance of avoiding undesirable elements of the population. Sethi and Somanathan (2003) provide a survey of theories of assortative matching.

We follow the latter approach in this paper, providing and experimentally testing a more flexible and 'realistic' mechanism for endogenous group-formation that includes possibilities for exit, exclusion, and mergers among groups. This addresses the question of whether the results from a standard public-goods game underestimate the contributions that would result in a more natural setting where these group formation tools are often available.

The basic structure of our mechanism for group evolution allows for an ebb and flow in a dynamic environment. There are four key features of our design. First, contributions are more valuable in larger groups. Second, the possibility of exclusion affords would-be cooperators insurance that they will be safe from would-be free-riders. Third, we permit 'redemption', whereby people who were initially excluded later become good citizens with high contribution rates. Finally, we implement mergers between groups, thus facilitating a more efficient process for combining existing cooperative groups. This allows groups to not only shrink by exit and banishment, but also to grow rapidly because their 'cooperative' looks attractive to other groups.[4] Field examples of mergers between groups include joint ventures between research consortiums and mergers between firms, where there are economies of scale involved. Municipal governments may also form larger groups for the purpose of sharing the cost of public goods.[5]

A number of recent papers have explored the topic of endogenous group-formation in public-goods games. We build upon this valuable previous work. As we also do, these papers enhance the standard public-goods environment with the addition of group-formation structures. For example, Ehrhart and Keser (1999) feature similar efficiency considerations, but without

[4] In previous studies, groups could only grow by adding individual members. Thus, if two groups wished to combine, one group would first have to dissolve itself.

[5] For example, in Lyon, France, there is the so-called "Grand Lyon" that merges together many villages and towns around the city in order to have more extended and diversified network activities in leisure and transportation. We thank Marie Claire Villeval for providing this example.

exclusion or entry requirements; the pattern is one of cooperative participants being on the run from free riders. Cinyabuguma, Page, and Putterman (2005) include exclusion, and achieve a high rate of contribution among those people not expelled from the original grand coalition. However, exclusion is irreversible and quite costly; over time more and more people are banished, with social efficiency eroding. We discuss other related papers in our literature review.

Our experiment has two treatments with endogenous group-formation. People play a public-goods game for three periods, with ID numbers showing individual contributions. We then allow exit, exclusion, and merger in three steps (described in Section 3). Three periods of play follow with the new groups, with this process continuing until 15 periods have been played. We have two such 15-period segments, with ID numbers changed for the second segment, thus allowing a fresh start. Each 'society' is comprised of nine individuals, who are initially randomly matched into three groups with three members in each group. In our first treatment, the value of the marginal unit of contribution increases with group size, so that larger groups are more efficient and the social optimum is achieved with full contributions in the grand coalition of nine people. Our second treatment is identical to the first except that, in order to explore the effect of social efficiency on behavior, we only increase the group's return from contributions up to a group size of four. In both of these treatments, we provide some friction by having the marginal per-capita return (MPCR) of contributing decrease with increasing group size.

Our results are striking, as we find a great degree of success for this mechanism in both of our treatments where it is used. We see considerable exit and exclusion, particularly in early rounds. The average contribution rate (excluding the final three periods of a segment) is quite high in our first two treatments. When rewards from increasing group size are not truncated, large and stable groups form, promoting efficiency: With truncation, contributions are slightly lower, with smaller groups and considerably more instability. The high level of contribution persists in each segment while subsequent voting for group members is expected.

The remainder of this paper is organized as follows. In Section 2, we provide a literature review, while we describe the experimental implementation in Section 3. We present the experimental results in Section 4. Section 5 offers a discussion of our results and remarks on methodology; we conclude in Section 6.

2. Previous Literature

Early experimental studies (e.g., Marwell and Ames 1979, Isaac and Walker 1988) focused on patterns in provision rates and on investigating the influence of group size on public contributions; in these studies, the group remains fixed for the duration of the experiment. Since these early studies, much of the experimental literature suggests that a key impediment to sustaining high contribution rates is the presence of 'bad apples.' It has been argued that people are particularly sensitive to uncooperative behavior, perhaps in the same way that people are considered to experience losses more strongly than gains. Thus, one possible approach is to enable would-be cooperators to avoid these free riders and join with like-minded individuals.

Ehrhart and Keser (1999) were the first to consider a public-goods game with endogenous group-formation. Nine participants were randomly placed into three initial groups and played the game. Each person was then told the sizes and average contributions for each group, and could unilaterally decide, at a fixed cost, to switch groups or to form a new (one-person) group. However, although there was considerable movement, this device had limited success. Without exclusion or an entry restriction, the pattern is one of more cooperative participants being on the run from free riders, who constantly chase them.

In Cinyabuguma, Page, and Putterman (2005), sessions began with 16 people in one group.[6] After each round, people voted on whether to expel individual group members, who were then irreversibly banished to a "fringe group" of undesirables who played a public-goods game with a lower endowment; thus, the group size can only decrease. There is significant expulsion, with an average of about 1/6 of the original group relegated to the fringe over the course of a session.[7] The rate of contribution in the main group was quite high; however, the contribution rate for the fringe group was very low (Figures 1 and 3 suggest that this contribution rate was between 5% and 10%).[8]

Page, Putterman, and Unel (2005) have four 4-person groups (initially randomly assigned) who play 20 rounds of a public-goods game. After every 3 periods, there is a regrouping where each person rates all other 15 participants based on the public information about everybody's average contribution there. The four people with the highest sum of mutual ratings form the first group. The same procedure determines the second and third groups, with the leftovers forming the last group. The average contribution improves from 38% in the baseline to 70%, but we still observe the standard decay due to free-riding in the worst-contributing group.[9]

Ahn, Isaac, and Salmon (2009) consider endogenous group-formation in three treatments, finding that the rules for exit and entry have substantial effects on behavior and outcomes. Their unconventional payoff function has a fixed individual marginal benefit for the total

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[6] This is in contrast to our design, where initial groups are small (perhaps the more natural case) and size changes can go both ways.
[7] This expulsion rate might have been higher with a different payoff function. Here, each person in the group received one's private contribution plus 20% of the total contributions made by group members. Thus, exclusion shrank the pool of potential contributions without providing any direct benefit to the remaining group members. See also Maier-Rigaud, Martinsson, and Staffiero (2005).
[8] Croson, Fatás, and Neugebauer (2006) also study endogenous excludability, but with a fixed and exogenous rule, in three different experimental games. The person who contributes the least is automatically excluded from receiving any of the group's payoffs; this leads to considerably higher contribution rates in the public-goods game and the best-shot game, with a smaller increase in the minimum-effort game. This is essentially a competition among the four players in a group, where the optimal outcome for a player is to be the second-lowest contributor.
[9] Similarly, Gunnthorsdöttir, Houser, MaCabe, (2007) secretly sort people into high and low contributing groups of fixed-size of four and find similar results, with bifurcations in the contribution level.

contributions in the group, so that adding a free rider does not decrease the payoffs of the other group members; however, the cost of contributing increased with the cube of the size of the contribution, so that a selfish actor would contribute a positive amount, but not the entire endowment.[10]

Finally, Weber (2006) finds that slowly building groups, after first establishing cooperative behavior in 2-person groups, can be effective in achieving high rates of contribution in the minimum-effort game with large groups (up to 12 people). Here it seems important for groups to first establish a norm and grow slowly. In the working-paper version (Weber 2005), a 'manager' selected at random from the participants can grow the group endogenously; managers typically try to simultaneously add multiple people to the group in the early stages, leading to a notable lack of success in achieving good outcomes in the larger groups.[11]

Unlike previous studies involving exclusion, we achieve our high rate of cooperation and efficiency without the very costly 'grim-trigger' punishment of permanent expulsion, as an excluded person often achieves redemption, becoming a highly-contributing member in another group or even the original group. Also, while cooperation is more valuable in larger groups, there is at least some congestion, so that the MPCR does drop with increasing group size, unlike the other studies with exclusion. Thus, in a certain sense our design represents a more difficult test for sustained cooperation, as the burden increases with group size.

3. Experimental Implementation

We conducted our experiments at the University of California at Santa Barbara, with

[10] Other studies on this topic include Riedl and Ule (2002), Coricelli, Fehr, and Fellner (2004), Brosig, Margreiter, and Weimann (2005), and Önes and Putterman (2007).

[11] Yang, Xu and Tang (2009) report an experiment that applies a simplified version of the current group-formation mechanism to an endogenous-size large group coordination problem. This design works without exclusion, and without allowing compound mergers in one period.

participants recruited from a campus-wide list of (primarily) undergraduate students who had previously indicated interest in participating in paid research experiments. None of the participants had any experience with public-goods or voting experiments.

In Treatment 1 (hereafter the "Main" treatment), we conducted four laboratory sessions with a web-based program; there were nine participants in the first session and 18 in each of the remaining three sessions, for a total of 63 participants in this treatment. The average income in these sessions (of about 90 minutes in length) was approximately $21, including a $5 show-up fee. Our supplemental, printed sample instructions are presented in Appendix A.

In this treatment, nine people in each 'society' were initially placed into three groups of three people and played a public-goods game for three periods. Each person was endowed with 25 tokens that could be allocated between a private account and a public account. The social value of an allocation to the public account depended on the group size, as shown in Table 1. We determined the group return by using the four-person MPCR of 0.4 as the standard, leading to a group return of 1.6 for the 4-person group. We increased (decreased) this factor by 10% for each additional (fewer) person in the group, except that the factor for a solitary individual was 1.

Table 1: Group returns and MPCR in Main treatment, by group size

n	1	2	3	4	5	6	7	8	9
Group return	1	1.322	1.455	1.600	1.760	1.936	2.130	2.343	2.577
MPCR	1	0.661	0.485	0.400	0.352	0.323	0.304	0.293	0.286

After the first three periods, individuals learned about the average contribution of each individual (by identification number) in one's current group in those three periods, as well as the average contribution in other groups. At this point, we proceeded with exit and exclusion. First, people could unilaterally decide whether to exit the group. Each person who elected to stay in their group voted on every other group member; if more than 50% of the voters chose to exclude an individual, that individual was expelled from the group.

At this point there were a number of groups, group remnants, and 'free agents' (individuals who were unmatched either voluntarily or not). Each of these entities then decided whether it wished to merge with each of the other entities, with information provided about the average contribution for the last three periods for each entity. A merger happened if and only if at least 60% of the members of each entity wish to merge with the other entity.

Our algorithm for performing group mergers began by considering whether the two largest groups (with ties broken randomly) wished to merge. If not, the mechanism considered the desires of the largest group and the third-largest group regarding a merger. This continued until a merger was achieved, at which point the process began again with the new two largest groups, etc. Ultimately, the process continued until no more mergers could be made. Any leftover singles were formed into new groups, depending on how many singles remained.[12]

The new groups then played three periods of the public-goods game with the same rules. There were voting rounds after the first four sets of three periods, with 15 periods overall in the segment. We then re-formed societies (except in the first session) with new identification numbers randomly assigned; a new 15-period segment was started with three three-person groups formed at random in each society.[13] Thus, in each session there were 30 periods of play in the public-goods game and eight voting rounds.

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[12] If there was exactly one single at the end of this process, he or she remained unattached. The details of this process can be found in the Instructions provided in Appendix A.

[13] We chose to have a re-start, as an individual might get locked into a situation that is difficult to escape during a segment, but instead would receive a fresh start in the second segment. We allowed the societies from one segment to mix in the second segment for at least two reasons. First, by comparing the patterns of behavior across the two segments, we can assess how much was learnt in the first segment. Second, mixing the groups across segments also helped to avoid the resumption of the behavioral patterns from the first 15-period segment.

Since we have a pre-determined number of periods, the only subgame-perfect equilibrium (with common knowledge of selfish preferences) is non-contribution. To see this, note that everyone will contribute nothing in the last three periods of a segment. Anticipating this, group size has no value in these periods, so everyone would contribute nothing in the penultimate three periods, etc. Implicitly, every player is indifferent about which group to belong, rendering the exits, exclusion, and mergers decisions irrelevant on the equilibrium path. In other words, in the standard game-theory framework, our setting is essentially not different from the one without our mechanism.[14]

Treatment 2 (hereafter the "Truncated" treatment) isolates the influence of efficiency considerations on contributions and group size. This treatment was identical to the Main treatment, with one important exception: the group return from contributions was set at 1.6 for all groups with four members or more. We had three sessions in this treatment (six societies), each with 18 participants. The average income in these sessions was approximately $18, including a $5 show-up fee. Table 2 shows the value of an allocation to the public account; there is no direct efficiency incentive to form groups larger than size four.

Table 2: Group returns and MPCR in Truncated treatment, by group size

n	1	2	3	4	5	6	7	8	9
Group return	1	1.322	1.455	1.600	1.600	1.600	1.600	1.600	1.600
MPCR	1	0.661	0.485	0.400	0.320	0.267	0.229	0.200	0.178

Treatment 3 (hereafter the "Baseline" treatment) featured fixed groups, in order to establish that our participants show similar behavior in the standard game to what has been observed previously. There were three sessions with 18 people in each. People were

[14] Of course, if we convert our game to one with a stochastic ending, we could sustain cooperation.

randomly assigned to a 3-person group, a 6-person group, or a 9-person group for a 15-period segment. We chose these size groups to get observations from small, medium and large groups. Each group simultaneously played the same public-goods game as in our main treatment, except that there was no endogenous group formation and no information was provided about the contributions of the other individuals or groups.[15] After the first segment, we randomly re-assigned people to new groups, so that the composition of groups varied across segments. Average income in these 45-minute sessions was about $13, including a $5 show-up fee.

4. Experimental Results

In this section, we first analyze our data at the group level. In section 4.1, we present descriptive statistics and some simple tests; in section 4.2 we offer analysis of individual behavior, as well as regressions regarding the determinants of exit, exclusion, and merger choices. We then consider redemption in section 4.3.

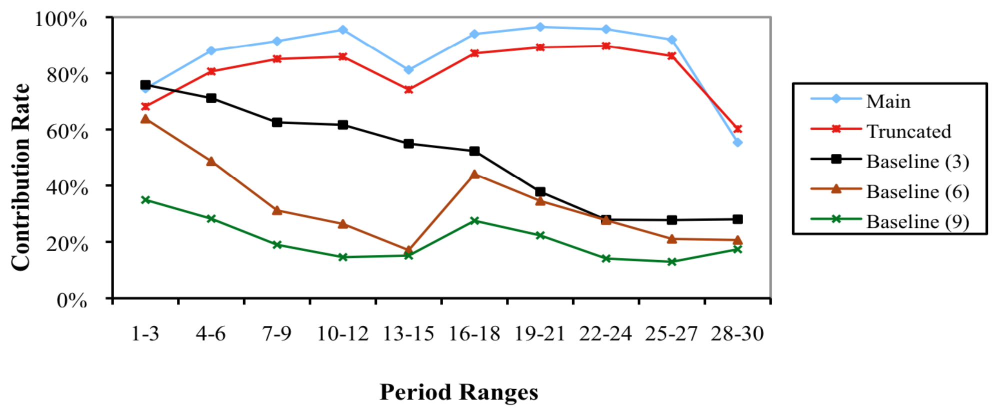
4.1 Descriptive statistics and simple tests

Figure 1 illustrates the average contribution rate over time.[16] We see that our mechanism induces high contribution levels in the Main and Truncated treatments, with a notable decrease in the last voting period of a segment. The average contribution profiles over time are remarkably similar for these treatments, with a 5-10 percentage point difference in contributions across these treatments in every period range except the last one; overall, the contribution rate in the Main treatment (excluding the last voting period and singles) is 90.9%, while the contribution rate in the Truncated treatment is 83.9%. Thus, when the multiplier increases with group size (at least

[15] We are indebted to Charles Holt for adapting his Veconlab software to make this possible.
[16] We exclude unmatched players (singles) from the calculations, as their contribution choices are arbitrary. There were only 24 cases in which an unmatched player chose a contribution out of 1170 cases in total, or about 2%. Thus, even assuming a zero-contribution rate for these singles would not affect the results substantially.

up to groups of size four), we observe a very high contribution rate. While the difference in contribution rates in these treatments is modest, it is statistically significant ($p = 0.029$, with the natural one-tailed test) on a Wilcoxon ranksum test using session-level data for median contributions.[17] Note the end-game effect in both the Main and Truncated treatments in periods 28-30, indicating that good behavior doesn't appear to be intrinsic; this drop is also echoed in periods 13-15.[18]

Figure 1: Average contribution rate over time



In the Baseline treatment, we see the familiar pattern of a moderate initial rate of contribution, followed by a severe decline over time. The contribution rate is highest in the 3-person game, intermediate in the 6-person game, and lowest in the 9-person game; the differences in contribution rates across fixed groups are largest in the beginning and diminish over time.[19] Endogenous group formation clearly generates a far higher contribution rate than

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[17] Using the median as a statistic minimizes the weight placed on outliers. The median contribution was 25 in each of the four Main treatments and was less than 25 in each of the three Truncated treatments. An alternative test uses the mean contribution in each session, finding $p = 0.057$, one-tailed test.

[18] While in theory we should observe unraveling all the way back to the beginning, it is more the norm than the exception in experiments to see unraveling only in the last period or two of finite-horizon experiments.

[19] Note that the contribution rate is very similar for the fixed 3-person group and the initial 3-person groups in the endogenous treatments in the first three periods, while contribution rates diverged thereafter. This suggests that behavior is learned over time.

in any of the fixed-group treatments. Making pairwise comparisons between each treatment, the Wilcoxon-Mann-Whitney ranksum test (see Siegel and Castellan 1988) of session-level data indicates statistical significance at $p = 0.029$ (one-tailed test) in each case for the Main treatment versus the Baseline and $p = 0.050$ in each case for the Truncated treatment versus the Baseline.[20]

Since a primary feature of our design allows group size to be endogenous, we examine how each 9-person society evolves over time.[21] In the Main treatment, group size grows steadily over the course of the first 15-period segment; group sizes are larger in the second segment. Overall, the most common endogenous decompositions were the grand coalition and an eight-person group with an unmatched single; in the second segment the grand coalition was the most common endogenous group. The pattern for the Truncated treatment differs considerably, as by far the most common endogenous decomposition was into subgroups of size two, three, and four. As there is no direct incentive to form a group with more than three other people, we observe no real trend towards increasing group size.

The frequency of various group sizes is revealing: There were 26 groups of size four in the Truncated treatment, compared to only one in the Main treatment. On the other hand, while there were 46 groups of size six or greater in the Main treatment, there were only seven such groups in the Truncated treatment. A related issue is the stability of the groups, here defined as whether a group stayed intact in the subsequent period. Overall, 78% of the larger groups (four or more people) in the Main treatment stayed intact, versus 43% in the Truncated treatment.

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[20] While it is true that we don't provide information concerning the contribution of each individual group member in the public-goods game version in the Baseline, the very large differences in contribution rates across the endogenous and fixed-group treatments and the fact that Croson (2001) finds no difference in average contributions according to whether or not this information is provided causes us to strongly suspect that our test result would hold in any case.

[21] Detailed decomposition results are shown in Tables B1 and B2 of Appendix B. Table C1 in Appendix C shows group sizes and mergers over time for each society in each treatment.

Groups larger than size five were *always* unstable in the Truncated treatment; in contrast, groups with more than five members were stable 75% of the time in the Main treatment.

Our final question in this subsection is the relationship between one's own contribution rate and one's profits: Does cooperation pay? This is the basic evolutionary question (and assortative-matching issue) to be answered. Yang, Yue, and Yu (2007) show there is a positive correlation between average payoff and how cooperative a player is overall. Of course, holding one's group size and the contributions of others in the group constant, the higher the contribution, the lower the profit. But it is obvious that contributions are a critical determinant of the size and character of one's (endogenous) group. In the Main treatment (excluding unmatched players and final voting periods), we obtain a Spearman coefficient (using average data for each individual as a single observation) of 0.5223, with $p = 0.000$; in the Truncated treatment, the Spearman coefficient is 0.5786, again with $p = 0.000$.[22] In Appendix E, we show the visual relationship between average contributions and profits for each individual.

We turn now to the effect of truncating potential efficiency gains at a group size of four. The results are clear concerning the number of large groups in each of these treatments. Session-level data show that the number of large groups was higher in each of the four sessions of the Main treatment than in any of the three sessions of the Truncated treatment. The Wilcoxon-Mann-Whitney ranksum test gives statistical significance at $p = 0.029$ (one-tailed test). Thus, larger groups do not tend to form when there is no payoff advantage for the larger groups.

The results regarding the effect of efficiency truncation on contribution rates are more mixed. Recall the strong similarity in Figure 1 in the contribution profiles over time for the two endogenous treatments, with a rather modest difference in contribution rates in nearly every voting period. Once again, the ranksum test can be performed using each society as one

[22] In this paper, we round off the p-value to three decimal places.

observation. The purest test uses data from the first segment, as there has been no interaction between societies. However, the data from the second segment has the advantage of perhaps better representing settled behavior. The Wilcoxon-Mann-Whitney test yields $p = 0.069$ using society averages in Segment 1 and $p = 0.018$ (one-tailed tests) using society averages in Segment 2.[23] Nevertheless, the difference in rates across treatments is quite modest; the mechanism achieves a high level of contributions even when the potential efficiency gain is much smaller (but still present).

4.2 Detailed analysis on group formation

<u>Exit</u>

Each person faced the exit decision at most eight times and exit was chosen only rarely (8.9% of the time in the Main treatment and 16.5% of the time in the Truncation treatment). The Wilcoxon ranksum test on individual exit rates finds a significant difference ($p = 0.003$) across treatments. The higher exit rate in the Truncation treatment is consistent with the lower degree of stability in this treatment.

While there is a considerable degree of heterogeneity with respect to the circumstances when one chooses to exit from one's group, there is nevertheless a clear overall relationship between one's contribution relative to the group average and the choice to exit. People chose to exit from a multi-person group significantly more frequently when their contribution was higher than the group average.[24] There is also a clear and significant relationship on the individual level between whether the average contribution of the other multi-person groups exceeded that of

[23] A similar approach that instead uses the average contribution of the median contributor in each society as one observation also finds significance: $p = 0.051$ (0.001) for one-tailed tests of the data from segment 1 (2).

[24] Fifty-four people (of 117) chose to exit at least once (excluding the last voting period). Thirty-four people chose to exit more frequently when their contribution was higher than the group average, compared to 12 people who chose to exit more frequently when their contribution was lower than the group average; the binomial test establishes that this trend is significant ($Z = 3.24$, $p = 0.001$).

one's own group and exit, with people more likely to exit when the average contribution of the other groups was higher.[25]

Table 3 shows the determinants of exit choice, in random-effect probit regressions excluding decisions, by singles and voting period 5. In both treatments and in all specifications, the difference between one's own contribution and the average ingroup contribution is a significant factor: the bigger this difference, the more likely that exit will be chosen. When contributions in one's own group are low, one might be tempted to look elsewhere. In this respect, the average contribution for the other existing groups is also a statistically-significant determinant of exit. In addition, there is an attraction to the maximum average contribution of the other groups, as there is a large coefficient for this term in specifications (3) and (6), as well as a high degree of significance.

Table 3 – Determinants of Exit Choice

Independent variables	(1) Main	(2) Main	(3) Main	(4) Truncated	(5) Truncated	(6) Truncated
Own contribution – average ingroup contribution	0.176*** [0.044]	0.152*** [0.045]	0.104** [0.044]	0.071*** [0.025]	0.099*** [0.030]	0.076** [0.031]
Average contribution of other groups		0.094*** [0.033]	0.121** [0.054]		0.101*** [0.031]	0.077** [0.033]
Maximum contribution of other groups			0.207*** [0.032]			0.156*** [0.026]
Constant	-2.034*** [0.213]	-3.920*** [0.787]	-5.103*** [1.321]	-1.158*** [0.130]	-3.237*** [0.663]	-3.304*** [0.727]
# Observations	493	493	493	425	425	425
Log-likelihood	-122.04	-113.03	-79.20	-180.79	-171.56	-148.82

Standard errors are in brackets. **, *** indicate significance at the 5% and 1% level, respectively

[25] Of the 54 people who chose to exit from a multi-person group at least once, 43 chose exit more frequently when the average contribution of the other groups was higher, while eight chose exit more frequently when this contribution was lower; the binomial test establishes that this trend is significant ($Z = 4.90$, $p = 0.000$).

Exclusion

Turning next to exclusion patterns, if a person has chosen to stay with the group, but is unhappy with the choices made by some of the group members, another option to consider is exclusion. Each person made exclusion decisions in up to eight voting periods, with a choice for each person in one's multi-person group. In total, there was an average of slightly more than 25 exclusion decisions for each participant. Eighty-three out of 117 participants (71%) chose exclusion at least once (excluding instances when the person voting for exclusion was the minimum contributor). Overall, exclusion was chosen 9.9% of the time; this was much more frequent in the Truncation treatment than in the Main treatment (18.7% versus 6.0%, respectively).[26] Again, the higher exclusion rate in the Truncation treatment is consistent with the lower degree of stability in this treatment. Typically, the minimum contributor was at least one of the excluded parties; in fact, in only four cases of the 234 instances where a non-minimum contributor chose exclusion was the minimum contributor not excluded. Overall, excluding votes by the minimum contributor, 85% of the exclusion votes went to the minimum contributor.

Table 4 reports the results of random-effects regressions vis-à-vis the decision of whether or not to exclude another group member, apart from voting round 5. We see quite strongly that an individual is more likely to exclude another group member the lower that member's contribution; this is the case in both treatments and all specifications. In addition, one's own contribution plays a role – if the other person's contribution is less than one's own, exclusion is considerably more likely. Finally, one is considerably more likely to exclude someone from the group if that person's contribution was the least in the group.

[26] The Kolmogorov-Smirnov test of cumulative distributions finds a significant difference in these distributions (p = 0.000); similarly, the Wilcoxon ranksum test on individual exclusion rates finds a significant difference (p = 0.000).

Table 4 – Determinants of Exclusion Choice

Independent variables	(1) Main	(2) Main	(3) Main	(4) Truncated	(5) Truncated	(6) Truncated
Other's Contribution	-0.208*** [0.015]	-0.121*** [0.017]	-0.109*** [0.018]	-0.202*** [0.016]	-0.140*** [0.017]	-0.129*** [0.018]
Ingroup minimum[27]		1.832*** [0.180]	1.153*** [0.289]		1.349*** [0.145]	0.828*** [0.178]
Contribution less than own			0.825*** [0.287]			0.852*** [0.185]
Constant	2.977*** [0.329]	0.543 [0.420]	0.196 [0.435]	3.364*** [0.337]	1.647*** [0.386]	1.144*** [0.340]
# Observations	2089	2086	2086	958	931	931
Log-likelihood	-312.50	-255.19	-251.39	-336.29	-277.76	-266.69
Standard errors are in brackets. *** indicates significance at the 1% level						

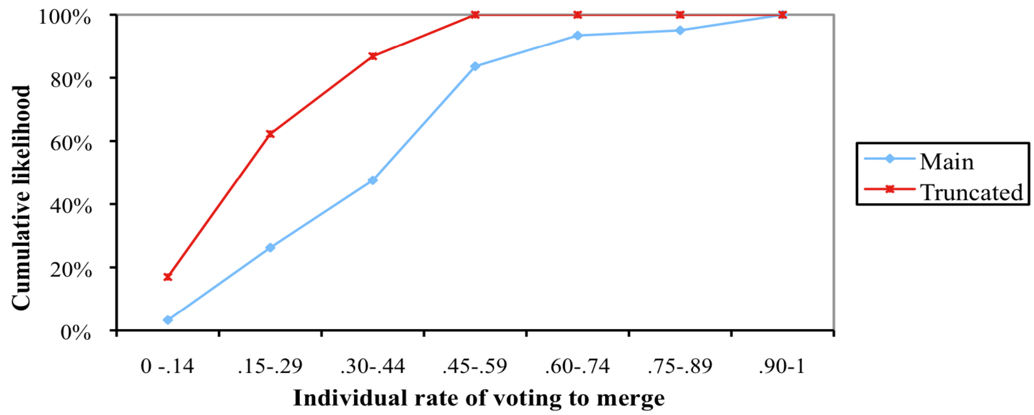
Merging

Once all exit and exclusion choices were made, one chose whether to merge with other groups. The overall rate of voting to merge (excluding merge choices by singles and the last voting period in each segment) was 42.0% in the Main treatment and 26.9% in the Truncation treatment.

Figure 5 shows the cumulative distribution of the individual rates of voting to merge. The difference in individual rates is highly significant in both the Wilcoxon test ($Z = 5.14$, $p = 0.000$) and Kolmogorov-Smirnov test ($p = 0.000$). Merging appears less attractive when the efficiency gains from larger groups are truncated when the group size is at least four.

[27] We eliminate ties in the regressions involving the ingroup minimum, so some observations are dropped.

Figure 5: Cumulative individual rates of voting to merge



Since we have a number of observations of positive and negative merge choices for each individual, we can perform useful individual regressions for the merge choice. To examine the motivation to merge, we construct a variable that reflects on whether a possible merger looks profitable, as rational players would prefer merger with another group if they expect to profit from such merger.[28] As the first benchmark for comparison, we consider that people would only consent to a merger if the (conservatively) expected payoff in the next round is higher than both one's payoff in the current round and the expected one for his current intermediate group for the case of no merger at all.

Let *n'* be the original group size before exit/exclusion, *n* (≤ *n'*) be the intermediate group size, *m* be the merger partner's size, and X_k be the total average contribution level of the respective group of size *k*. We define the variable *S*, which reflects the incentive difference.

$$S = \frac{f(n+m)\cdot(X_n + X_m)}{n+m} - (1-D_{excl})\max\{\frac{f(n)X_n}{n}, \frac{f(n')X_{n'}}{n'}\} - D_{excl}\cdot 25$$

[28] This variable only applies in voting periods other than the last one in a segment, as these exhibit significant unraveling while the others do not.

Note that if the decision maker is voted out at the exclusion stage (dummy D_{excl} =1), then she should be clear that merger failure would result in an involuntary and random group of 1-3 persons. Thus, a pessimistic view would be that staying single yields a payoff of 25.[29] We also make the conservative assumption here that subjects have a rather myopic perspective, in that they only consider payoffs in the next round. If we ignore exclusion, the above formula can be simplified as follows.

$$S = \frac{f(n+m)\cdot(X_n + X_m)}{n+m} - \max\{\frac{f(n)X_n}{n}, \frac{f(n')X_{n'}}{n'}\}$$

We perform individual regressions for the merge decision against *S*, and obtain non-degenerate results for 109 of the 117 participants. The coefficient on *S* is negative in only four cases, clearly far from random behavior. Eighty of these regressions find a positive coefficient for *S* that is significant at the 5% level (no negative *S* coefficients are significant).[30] Thus, the expectation of future profit clearly drives the decision to merge, at least for most people.

The median *S* coefficient is 0.235. Of course the size of the coefficient varies considerably across the population. Figure 6 shows the distribution of these coefficients. In addition, Table 5 shows the aggregate-level determinants of the merger decision in simple regressions. A merger is more attractive if the other group has made higher contributions; further, the larger the other group, the more interest in merging with it. These forces are quite significant and strong. In addition, the smaller the average contribution in one's own group and the smaller one's own group size, the more attractive a merger becomes for the members of the group.

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[29] Note that $\frac{f(n)\cdot X_n}{n} = 25$ if $n = 1$.

[30] This reflects a one-tailed test, on the hypothesis that people are more likely to choose to merge when *S* is positive; 66 coefficients are significant with a two-tailed test.

Figure 6: Individual S coefficients

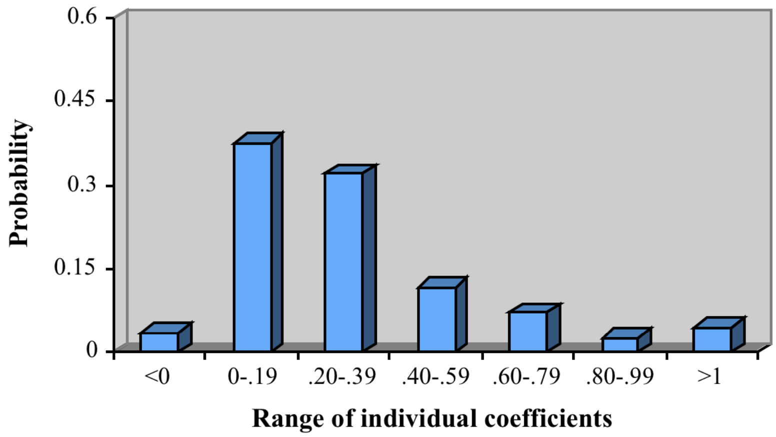

Table 5 – Determinants of Merger Choice

	Dependent Variable			
Independent variables	(1) Main	(2) Main	(3) Truncated	(4) Truncated
Outgroup contribution	0.127***	0.139***	0.153***	0.188***
	[0.010]	[0.010]	[0.010]	[0.011]
Outgroup size	0.245***	0.217***	0.236***	0.137***
	[0.041]	[0.043]	[0.040]	[0.042]
Own group contribution		-0.037***		-0.073***
		[0.013]		[0.010]
Own group size		-0.061**		-0.030
		[0.030]		[0.036]
Constant	-2.965***	-2.174***	-3.748***	-2.131***
	[0.192]	[0.274]	[0.204]	[0.257]
# Observations	1147	1147	1830	1830
Log-likelihood	-560.13	-548.58	-884.49	-787.19

Standard errors are in brackets. **, *** indicate significance at the 5% and 1% levels

3.3 Redemption

One novelty of our design is that it allows people who have been ostracized to experience redemption, as evinced by a pattern of small initial contributions and larger contributions in late rounds. These are people who presumably would have been permanently excluded in studies featuring irreversible exclusion. The concept of ostracism goes back at least to the days of Athens, where a constitutional safeguard called *ostrakismos* is considered to be an element in the stability of the Athenian democracy. Citizens could vote on whether to banish other citizens who were too powerful or wealthy or who otherwise threatened the unity of the society; an individual who received too many votes was banished for a period of 10 years.[31] We feel that reversible exclusion is a more accurate representation of the field environment than is permanent exclusion, given that people typically tend to relent or renegotiate.

Depending on which classification scheme is used, approximately 20% of the participants achieved redemption, with a higher redemption rate in the main treatment.[32] Thus, providing the possibility for people who have made mistakes early in their 'lives' to later join a group enables a large proportion of society to become productive members of society. We present each individual's contributions over time and classification with respect to redemption in Appendix D (Tables D1 and D2).

If these participants were excluded irreversibly, it would greatly impact social efficiency. For example, if three people from a nine-person society were permanently excluded, there would

[31] In fact, animals also sanction non-contributing members by ostracism (Goodall 1986, Lancaster 1986).
[32] If we define redemption as having contributed 50% or less in either the first or second voting rounds in the first segment and at least an 80% average in the four non-final voting rounds in the second segment, then 7 of 63 people in the main treatment and 13 of 54 people in the truncated treatment (20 of 117 overall) achieved redemption; with a definition involving 60% and 90%, this becomes 16 of 63 and 9 of 54, respectively (and 25 of 117 overall); with a definition involving 60% and 95%, this becomes 16 of 63 and 7 of 54, respectively (and 23 of 117 overall). While these alternative definitions are not cast in stone, the pattern nevertheless seems clear and robust.

be at best a 6-person group and a 3-person group formed from those who were banished.[33] This gives an average multiplier of 1.776; in a nine-person group made feasible with redemption, the multiplier is 2.577. Thus, the maximum potential social efficiency with redemption is 45% higher than otherwise.[34] In short, a non-grim-trigger strategy seems a desirable feature.[35]

5. Discussion

Our mechanism is successful in achieving a high rate of contribution in both treatments. In the Main treatment, we find a pronounced tendency towards endogenously forming large, full-contribution groups, thus promoting a high degree of efficiency; group sizes are smaller in the Truncation treatment, but contributions remain fairly high. We often see the grand coalition formed in the Main treatment, even though we start with small building blocks and have only a few voting rounds to get there. This is clearly due to the possibilities for exit, exclusion, and mergers, since cooperation dissipates when these actions are no longer possible, both in the last three periods of a segment and in our control experiments. Analysis of individual-level data shows a substantial degree of heterogeneity, but indicates predominant influences on behavior.

Our results seem largely driven by two major elements. First, increasing returns to scale seem needed for large and inclusive groups to form; if these are truncated at some group size less than the number of members in the society, there is less stability and lower relative efficiency. Since the presence of economies of scale seems to be a natural feature for public-goods problems in general, it is important to deal with truly endogenous group sizes. Second, it is very helpful that would-be cooperators understand that they have insurance against 'selfish' behavior by

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[33] Social efficiency would be even lower if these three people were not grouped together.

[34] In practice, the average earnings per period were 45.6 in the Main treatment and 34.6 in the Truncation treatment.

[35] We note that Ali and Miller (2010) show theoretically that when individuals interact with each other on a social network, permanent ostracism is unsustainable; on the other hand, temporary ostracism achieves the maximal gains from trade that can be achieved by any sub-game perfect equilibrium.

people in their group. A strong (and rationalizable) belief that a grand coalition or other large group will form may suppress one's inclination towards free-riding right from the start.[36]

While cooperation is more valuable in larger groups, there is at least some congestion, so that the MPCR does drop with increasing group size, unlike the other studies with exclusion. Thus, in a certain sense our design represents a more difficult test for sustaining cooperation, as the burden increases with group size. Another key issue concerns the degree of information required to achieve successful outcomes. Nearly all of the other studies mentioned provide complete information regarding the contributions (or effort) provided by each of the participants in the session. This is a strong and perhaps unrealistic requirement. It seems more in the spirit of Tiebout (1956) to have information shielded by the group boundaries; while one might be able to observe the total output of a group or firm to which one does not belong. In our environment, we do not allow the inner workings of each group to be exposed as long as the group is intact.

A critical element for our results is that free-riders are not able to exploit cooperators on a long-term basis. Conditional cooperators who succeed in avoiding free-riders will make large contributions in our endogenous group-formation treatments.[37] Furthermore, a non-myopic free-rider may well cooperate strategically, as it rapidly becomes apparent that contributing nothing will very likely lead to being unmatched (or matched involuntarily with other undesirables), with an average payoff near 25. Even if one has selfish preferences and understands the equilibrium if everyone has such preferences, own-payoff-maximization may require full contribution, given expectations that a sufficient number of others will contribute.

People base their current actions on what they expect the future to be, and particularly on

[36] Note that the significantly higher starting average rate of contribution in the second segment is support for the view that people form such beliefs.

[37] See Chaudhuri (2007) for a survey of the literature on conditional cooperation and social norms in public-goods experiments.

how their own actions may affect this future. The precise conditions under which a purely selfish individual should choose cooperation over free-riding will depend on beliefs, but cooperation will not be so rare given the payoff attraction of large groups.[38] The outlook of the efficiency potential of large groups,[39] combined with the expectation of such large groups forming, makes current risky actions worthwhile and cooperation is sufficiently safe-guarded by the endogenously severe impact of exclusion. Thus, we see behavior in our setting as being primarily determined by a combination of non-myopic own-payoff maximization and altruism.

We must also explain the unraveling in the last round of each segment of the endogenous treatments. Our explanation is that some of the free-riders who have been masquerading as cooperators realize in the first period of the last round that there is no longer *any* strategic reason to make positive contributions, and so they stop doing so. This leads to the light progressively dawning on other free-riders, and conditional cooperators abandoning cooperation in the face of increasingly selfish behavior. The higher zero-contribution rate in the second segment reflects learning that it is not uncommon for people to stop contributing in the last round of the segment.

Methodological Discussion

Standard wisdom in experimental design is to only change one factor at a time, in order to uniquely and clearly identify the cause of the change in outcome across different treatments (for example see Davis and Holt, 1995). However, this typical (reductionist) methodology has

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[38] For example, consider a person with selfish preferences in an *n*-person group at the beginning of the penultimate voting round of a segment, who is pondering whether to free ride or to stick to the norm. Free riding leads to expulsion. Thus her average per-period payoff in this case is: $(25 * f(n) * \frac{n-1}{n} + 25) + 25$. If she postpones free-riding to the last voting period while sticking to the norm of full contribution in the penultimate voting round, then she expects an average payoff of $25 * f(n) + (25x * f(n) * \frac{n-1}{n} + 25)$, where x denotes the aggregate % of contribution from other group members. For the person to not free-ride in the penultimate voting period, the first expression must be no greater than the second. In the Main treatment, x must be greater than 31% (50%) if he is in a 9-person (4-person) group. In the Truncated treatment, x must be greater than 57% (50%) for these group sizes. There is a correspondingly greater incentive to stick to the full-contribution norm within large groups in earlier rounds.

[39] See Charness and Yang (2008) for a precise definition of "efficiency potential."

some limits for real-world scientific research. For example, real-world systems often function based on a set of complementary factors.[40] In such a case, if one changes the environment by one factor at a time and does not identify all of the relevant factors, it may appear that no single factor has any effect. We chose a different approach, where we include several changes from previous designs and succeed in achieving a very high rate of contribution. Of course, one should then proceed to try to determine (through variations of sets of factors) the essential complementary elements in the design. Our initial study in this realm does not attempt a complete decomposition.

We cannot provide definitive evidence in one single study regarding whether all of entry barriers, exit, exclusion, and merging are needed for a high degree of contribution in our environment. However, we can in fact draw some inferences from our results and from comparisons to previous work. For example, the Ehrhart and Keser (1999) design, which includes the economy of scale featured in our main treatment, demonstrated that there must be at least some entry barrier (or exclusion option) to avoid the "on-the-run" outcome without group stability or high contribution rates. Our design does provide some evidence regarding the effects of the economy of scale on behavior, as truncating the economy of scale at n =4 leads to substantially less stability in large groups and a decreased level of contribution of 5-10 percentage points. In this treatment, members of the best group(s) are not willing to take on more applicants, which would be efficiency-enhancing as more people would enjoy the highest rate of public-goods production.[41]

The fact that exclusion is used by over 70% of the participants suggests that it is an

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[40] Milgrom and Roberts (1994) argued eloquently that the Japanese economic system that excelled up until the mid-1980s was based on many complementary features from economic to social and cultural institutions, and that its later failure reflected the inability to maintain stability in some of those institutions due to (forced) globalization.

[41] The most efficient group structure in this treatment is either one group of four and one group of five or a 9-person group. But neither case was ever observed.

important feature. But it is indeed used much oftener and apparently less effectively in the Truncation treatment. While the system could potentially work without the exclusion option, we suspect that some people would temporarily masquerade as high contributors until joining a group and then become free riders.[42] In this case, it seems necessary to permit exit, although Ehrhart and Keser (1999) show that exit alone (even combined with economies of scale) is ineffective. Finally, some kind of entry barrier is needed to enable stable growth in the group size. Our specific rule for mergers between groups simply serves to accelerate the process; while we might not observe the same effectiveness in the limited number of rounds in our design with other rules, one might expect similar results over a considerably longer horizon.

One objection to our design is that Cinyabuguma et al. (2005) showed that, given a large group already in place, the one-factor change of adding the exclusion option can be very effective at increasing contributions. However, one could argue that a driving force is the very high (and exogenous) opportunity costs of being expelled, due to the irreversibility of expulsion and a far less attractive payoff structure for people who have been excluded; in comparison, the opportunity costs to exclusion in our design are endogenous. It appears likely that as long as the opportunity costs are exogenously set high enough, one can enforce any rules or achieve any level of efficiency with apparent one-factor change. Thus we feel that it is not the exclusion option *per se* that leads to high contributions; it is rather a facilitating factor that helps when the institutional environment fits. In addition, without an explanation of how the grand coalition forms in the first place, the Cinyabuguma et al. (2005) setup needs to be framed into a two-way endogenous environment to be more realistic.[43]

[42] Furthermore, the difference observed between the main and truncated treatments suggests that exclusion is not sufficient to yield the desired efficiency results.
[43] It is also worth mentioning that Page, Putterman, and Unel (2005) implicitly have a voting mechanism that achieves a fair degree of success (the average contribution rate for the best of the four groups is comparable to our

Thus, while we do not pretend to have separately identified the impact of each factor in our design, we do provide some insights. At minimum, the 'top-down' approach we have taken provides evidence that a very high rate of contribution and efficiency is feasible with endogenous group-formation, even when starting with small groups and allowing the opportunity costs for exclusion to vary endogenously.

6. Conclusion

We provide an endogenous sorting mechanism in a public-goods environment, where the issue of how to implement collective action in the face of potential free-riding is a crucial one. We find a great degree of success for this mechanism, with the average contribution rate quite high in two treatments with endogenous exit, exclusion, and merger; this contribution rate is slightly (but significantly) smaller in the second treatment, where we cap the social value of a contribution, so that there is no additional efficiency advantage to forming a large group.

Our design offers safeguards that make it difficult for myopic free-riders to seriously interfere with the endeavor of smart "conditional cooperators". The driving force appears to be the economies of scale combined with the awareness that bad behavior will result in screening in the form of not being able to join a group or being expelled from one. We also feel it is useful for established groups to have a possibility of joining together for their mutual benefit; in our design, mergers serve as a complement to the scale economy and we find that cooperative groups can grow quickly. A critical element is the greater efficiency in larger groups, while another very helpful element is the insurance that would-be cooperators have that they will be able to

overall rate). However, not everyone participates in this success (for example, the lowest group's average contribution rate is only 38%; one such group only had a 5% contribution rate). In contrast, 103 of 117 people (88%) in the second segment of our Main and Truncated treatments contributed at least 80% (excluding the final voting round and the four instances when a participant was a single), with 87 of 117 people (74%) contributing at least 90%.

ward off would-be free-riders. Finally, the possibility of redemption (reversible exclusion) makes it possible to achieve a substantially higher degree of social efficiency.

Ours is an approximation of how groups (and groups of groups) can evolve, adapted so it is manageable for conducting experiments while preserving the essential features. The mechanism differs from those in previous studies with respect to being fluid and dynamic; we provide a general and flexible platform to address both increases and decreases in endogenous size. Change is a prominent feature of society, and allowing both inflows and outflows between and among groups seems a better representation of the environment in the field.

We view our design as a reference point for what can be achieved with a bi-directional assortative group-formation mechanism. While we have established that this mechanism *can* work, we have not yet established the threshold conditions that must be satisfied. Different specifications regarding the rules of voting, the production function for public goods, the information available, and the degree of friction present may cause completely different inner dynamics of evolution of cooperation. We have begun the process of decomposing the mechanism, by truncating the efficiency of the production function above a group size of four; in this case, we find that contributions are slightly (but significantly) lower, with considerably less stability and smaller groups. Other possible changes include limiting the information available at the time of exclusion and exit, or even dropping the exclusion option altogether, which may however greatly delay the process towards efficiency. In future work, we will explore the boundary of cooperation within this general setting.[44]

[44] In fact, this process is under way. As mentioned in footnote 10, in an endogenous-size coordination study with economies to scale, Yang, Xu and Tang (2009) modified the current design by dropping the stage of exclusion and restricting the process to at most one merger for each group at a time.

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Appendix A

INSTRUCTIONS

Welcome to our experiment. You will receive $5 for showing up, in addition to your earnings from the session. There are 18 participants in the session. These participants will be subdivided into two *societies* of nine people each, with one's society determined by a random draw. You will not know which participants are in your society.

There will be a total of 30 periods in the session, comprised of two segments of 15 periods each. In each period, you will be in a *group*. All groups once formed remain intact for three periods. For the first 3 periods of each 15-period segment, we will randomly form 3 groups of 3 participants within each 9-person society (these societies will not be the same in the 2 different segments.) After this, groups will be formed based on the votes of the participants in the society.

Each individual's has a unique identification number over a 15-period segment; this identification number is randomly re-drawn in the second 15-period segment.

Once the groups are formed, each person will receive 25 tokens in each period and will make choices regarding individual and group allocations. The choice is how many tokens to allocate to the *group account* and how many to allocate to one's *private account*. Each token allocated to one's private account pays one unit to that individual, independently of the group size. On the other hand, each token allocated to the group account yields a return higher than one unit and all members of the group share equally the returns from the tokens allocated to the group account. Moreover, the rate (multiplying factor) of return increases with the group size. The table below shows the factor for each group size:

n	1	2	3	4	5	6	7	8	9
Factor	1	1.322	1.455	1.600	1.760	1.936	2.130	2.343	2.577
Per-person return	1	0.661	0.485	0.400	0.352	0.323	0.304	0.293	0.286

Thus, for the same amount of tokens allocated to the group account, larger groups will earn more money. On the other hand, the per-person return from the same amount allocated to the group account diminishes as the group size increases.

So, for example, if in a **four-person group** the total number of tokens in the group account is 10, then the total return to the group from the group account is 16, and each person receives a payoff of 4 units from the group account. For every additional token invested in the group account, everyone receives an additional return of 0.4 units (1.600/4), while whoever makes the additional contribution will have one unit less available for his/her private account.

By comparison, if in a **seven-person group** the total number of tokens in the group account is 10, then the total return to the group from the group account is 21.3, and each person receives a payoff of 3.04 units from the group account. For every additional token invested in the group account, everyone receives an additional return of 0.304 units (2.130/7), while whoever makes the additional contribution will have one unit less available for his/her private account.

In the beginning of the 15-period segment, each person is initially assigned to a three-person group. There are three periods of decisions made about the allocation of tokens before people vote on possible changes of groups. After each period, each person learns only his or her group's total (average) contribution level to the group account.

As mentioned above, groups remain intact for three periods and are then re-formed for the next three periods. We first allow each person to exit voluntarily from his or her group, and then the people remaining in each group decide if they wish to exclude any remaining group members from the group. Then, mergers among the group remnants and voluntary and involuntary singles will be considered. Here is how the process of group formation works:

Stage 1. Prior to voting, each person is told the average contribution level for every individual. in his or her *own* group, and the average for every existing group, during the past 3 periods. Each person then chooses whether he or she wishes to stay in his or her current group. If the answer is "no", he or she will be considered a "single" temporarily and will not participate in the following voting among those who chose "yes". If the answer is "yes", then this person casts a vote with respect to each other member of the group, regarding whether to keep the other person in the group. After this voting round, those persons who choose to stay in the group and who receive at least 50% *positive* votes from the other willing-to-stay group members remain in the group. All others are considered "singles" temporarily.

Stage 2. At this point, we have a number of groups (group remnants) and perhaps a number of single participants not in groups. Each person will now be told the average contribution for the past three periods for each of these temporary entities (groups or singles), as well as the composition (identification numbers) of these entities. For mergers among those entities, now each person casts a vote about **every other** entity in his or her society, expressing whether he or she would like his or her current group (or single) to merge with each other entity (group or single).

Stage 3. Groups are now re-formed based on these votes. We rank the groups remaining after Stage 1 by size, with random ordering for groups with the same size. Next, we check to see whether the largest group wishes to merge with the next-largest group, which may also be a "single". If we do not have *mutual approval* of this merger, we check whether the largest group and the third-largest group wish to merge etc. till one such merger takes place. If there are no such mergers with this largest group, we check the next-largest group in combination with the smaller groups. *Whenever there is a merger, we repeat the same procedure starting with the now-largest group*. We continue this process until we cannot find two groups (singles included) that wish to merge.

For *mutual approval* of a merger, we require that, <u>for each group</u>, at least 60% of the votes are in favor of merging with the other group. Note however that all votes are carried over after each merger as illustrated in the following example. Suppose there are three intermediate groups A, B, and C of sizes 3, 2, and 1. The group A's votes for mergers with B and C are 1/3 and 2/3 respectively. B's for A is 2/2, for C is 1/2. C's are 1/1 for A and 1/1 for B. According to our procedure, the first merger is A with C. This new intermediate entity AC's vote for B, now, is 2/4, while B's for AC becomes 2/2*3/4 + 1/2*1/4 = 7/8 as this new entity AC is composed to 3/4 of the old A and to 1/4 of the old C.

There may be single participants remaining at the end of this process. If there is more than one such single participant remaining, these participants will be randomly grouped into 3-person and 2-person groups, in group formats of 3-3-3, 3-3-2, 3-2-2, 3-3, 3-2, 2-2, 3, 2, if there are 9, 8, 7, 6, 5, 4, 3, or 2 singles, respectively. If only one is left, he will be a single through the next 3 rounds.

At the end of the experiment, we will add up your payoffs from all 30 periods and convert them to actual dollars at the rate of $0.01 for each unit. We will then pay each participant individually and privately. Thank you again for your participation in our research.

Appendix B

Table B1: Frequency of decompositions of the 9-person societies in Main treatment over time

	Decompositions								
	(2,2,2,3)	(3,3,3)	(2,3,4)	(2,2,5)	(1,2,6)	(3,6)	(2,7)	(1,8)	(9)
Periods 1-3		7							
Periods 4-6	1		1	4		1			
Periods 7-9				3	1		3		
Periods 10-12				1			2	4	
Periods 13-15					1		2	1	3
Periods 16-18		7							
Periods 19-21						2	1	2	2
Periods 22-24						2		2	3
Periods 25-27						1	1	2	3
Periods 28-30						1	2	2	2
Total	*1*	*14*	*1*	*8*	*2*	*7*	*11*	*13*	*13*

Table B2: Frequency of decompositions of the 9-person societies in Truncated treatment over time

	Decompositions										
	(2,2,2,3)	(3,3,3)	(1,2,2,4)	(2,3,4)	(1,4,4)	(2,2,5)	(1,3,5)	(1,2,6)	(3,6)	(2,7)	(1,8)
1-3		6									
4-6				4		1		1			
7-9				3	1	1	1				
10-12				3		1			1		1
13-15	2		1	2				1			
16-18		6									
19-21		1		3		1					1
22-24	1			1	1	2		1			
25-27	1			3		1				1	
28-30	1	1		2		2					
Total	*5*	*14*	*1*	*21*	*2*	*9*	*1*	*3*	*1*	*1*	*2*

Appendix C

Table C1: Group sizes and mergers over time, by Session, Society, Segment

	VP1	VP2	VP3	VP4	VP5
Main treatment					
1,1,1	3-3-3	*5-2-2*	5-2-2	*8-1*	8-1
1,1,2	3-3-3	**9-0**	9-0	8-1	8-1
2,1,1	3-3-3	4-3-2	*6-2-1*	7-2	7-2
2,2,1	3-3-3	*6-3*	7-2	8-1	9-0
2,1,2	3-3-3	*6-3*	*9-0*	9-0	9-0
2,2,2	3-3-3	**8-1**	8-1	8-1	7-2
3,1,1	3-3-3	*5-2-2*	5-2-2	5-2-2	6-2-1
3,2,1	3-3-3	*5-2-2*	5-2-2	*7-2*	7-2
3,1,2	3-3-3	**7-2**	6-3	7-2	*7-2*
3,2,2	3-3-3	6-3	6-3	6-3	6-3
4,1,1	3-3-3	3-2-2-2	**7-2**	8-1	9-0
4,2,1	3-3-3	*5-2-2*	*7-2*	8-1	9-0
4,1,2	3-3-3	**9-0**	9-0	9-0	9-0
4,2,2	3-3-3	**8-1**	8-1	9-0	8-1
Truncated treatment					
5,1,1	3-3-3	4-3-2	4-3-2	*6-3*	4-2-2-1
5,2,1	3-3-3	*6-2-1*	5-3-1	*8-1*	6-2-1
5,1,2	3-3-3	5-2-2	*5-2-2*	5-2-2	3-2-2-2
5,2,2	3-3-3	4-3-2	4-3-2	4-3-2	4-3-2
6,1,1	3-3-3	*4-3-2*	4-4-1	4-3-2	3-2-2-2
6,2,1	3-3-3	*5-2-2*	*5-2-2*	5-2-2	4-3-2
6,1,2	3-3-3	**8-1**	6-2-1	7-2	5-2-2
6,2,2	3-3-3	4-3-2	3-2-2-2	3-2-2-2	3-3-3
7,1,1	3-3-3	*4-3-2*	4-3-2	4-3-2	3-2-2-2
7,2,1	3-3-3	4-3-2	4-3-2	4-3-2	4-3-2
7,1,2	3-3-3	3-3-3	*5-2-2*	4-3-2	5-2-2
7,2,2	3-3-3	4-3-2	4-4-1	4-3-2	4-3-2

Entries show the groups existing at the start of the voting period. Entries in italics mean that there was one merge between two multi-person groups during the previous voting period; entries in bold mean that there were two such merges. The numbers (x,y,z) in the first column refer to (Session number, Society, Segment). Thus, for example, in the fourth row we have that for society 2 in the first segment of the second session, there were initially three 3-person groups. Prior to voting period 2, there were 6-person and 3-person groups, where there had been one merge between multi-person groups in voting period 1.

Appendix D

ID	VR 1	VR 2	VR 3	VR 4	VR 5	VR 6	VR 7	VR 8	VR 9	VR 10
1	7.3	**19.0**	23.7	19.0	***25.0***	25.0	25.0	23.0	***0.0***	***0.0***
2	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	16.7
3	13.3	21.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
4	10.0	21.7	**22.3**	25.0	25.0	25.0	25.0	25.0	25.0	16.7
5	12.3	12.7	**12.7**	*25.0*	25.0	24.0	24.7	24.3	25.0	25.0
6	11.7	**18.0**	24.0	25.0	25.0	25.0	25.0	24.3	25.0	25.0
7	8.3	25.0	25.0	25.0	25.0	24.3	25.0	24.7	25.0	23.7
8	16.7	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
9	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
10	13.0	**7.7**	7.7	**10.3**	**5.7**	16.0	***24.7***	***25.0***	*8.3*	**8.3**
11	20.0	**23.0**	***25.0***	25.0	**25.0**	25.0	25.0	25.0	25.0	13.3
12	25.0	25.0	25.0	25.0	16.7	25.0	25.0	25.0	25.0	0.0
13	13.0	**21.7**	25.0	25.0	25.0	25.0	25.0	25.0	25.0	2.7
14	21.7	25.0	25.0	25.0	16.7	25.0	25.0	25.0	25.0	16.7
15	20.3	25.0	25.0	25.0	25.0	25.0	25.0	25.0	6.7	**25.0**
16	25.0	25.0	25.0	25.0	20.0	25.0	25.0	25.0	25.0	25.0
17	13.7	**15.3**	**17.0**	***25.0***	24.7	23.3	25.0	25.0	25.0	15.0
18	21.7	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	8.3
19	16.0	**20.7**	**25.0**	25.0	25.0	25.0	25.0	25.0	25.0	25.0
20	18.3	**25.0**	25.0	25.0	25.0	25.0	25.0	25.0	25.0	8.3
21	4.7	**18.3**	20.7	**23.3**	**25.0**	25.0	25.0	25.0	25.0	25.0
22	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
23	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
24	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	8.3
25	20.3	25.0	25.0	25.0	8.3	25.0	25.0	25.0	25.0	8.3
26	25.0	25.0	25.0	25.0	0.0	25.0	25.0	25.0	25.0	0.0
27	21.7	**25.0**	25.0	25.0	25.0	25.0	25.0	25.0	25.0	21.7
28	23.3	25.0	25.0	25.0	16.7	25.0	25.0	25.0	25.0	8.3
29	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	0.0	0.0
30	10.0	16.7	19.0	25.0	25.0	6.7	**8.3**	**8.3**	**1.7**	**3.3**
31	15.0	**19.3**	20.0	22.3	25.0	24.7	25.0	25.0	25.0	25.0
32	13.3	**16.7**	**20.0**	**21.3**	***23.3***	11.7	**12.0**	**3.3**	**2.7**	**2.7**
33	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	0.0
34	25.0	25.0	25.0	25.0	16.7	25.0	25.0	25.0	25.0	1.7
35	9.3	16.0	21.7	25.0	25.0	24.0	25.0	25.0	25.0	16.3
36	23.3	24.3	25.0	25.0	11.7	25.0	25.0	25.0	25.0	11.7
37	19.3	25.0	25.0	25.0	25.0	23.3	25.0	25.0	16.7	**0.0**
38	13.0	**13.0**	**6.3**	**4.0**	3.0	4.3	**5.3**	**2.7**	**2.7**	**3.0**
39	18.7	**18.3**	20.0	24.0	25.0	21.7	25.0	25.0	25.0	25.0
40	21.3	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	8.3
41	23.3	25.0	25.0	25.0	25.0	24.0	25.0	25.0	25.0	3.3
42	13.0	**15.0**	**17.7**	**24.7**	20.7	22.7	24.7	**24.3**	25.0	22.7
43	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	16.7
44	18.3	24.0	25.0	25.0	19.3	20.7	**25.0**	**25.0**	**25.0**	25.0
45	7.7	**11.3**	**6.0**	**11.7**	10.0	17.7	**21.7**	**24.7**	**25.0**	24.0

46	23.3	25.0	25.0	25.0	3.3	25.0	25.0	25.0	25.0	12.7
47	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
48	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
49	14.0	**20.3**	18.0	***25.0***	25.0	25.0	25.0	25.0	25.0	16.7
50	21.7	25.0	25.0	25.0	8.3	25.0	25.0	25.0	25.0	10.0
51	15.0	**18.3**	**23.3**	25.0	16.7	25.0	25.0	25.0	25.0	8.3
52	16.7	**21.7**	25.0	25.0	25.0	25.0	25.0	25.0	25.0	0.0
53	25.0	25.0	25.0	25.0	0.0	25.0	25.0	25.0	25.0	0.0
54	15.0	19.0	**25.0**	25.0	25.0	25.0	25.0	25.0	25.0	16.7
55	25.0	25.0	25.0	25.0	16.7	25.0	25.0	25.0	25.0	0.0
56	18.0	22.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	4.0
57	20.0	**25.0**	25.0	25.0	25.0	25.0	25.0	25.0	25.0	21.7
58	21.7	**21.7**	**21.7**	***25.0***	23.3	23.3	25.0	25.0	25.0	23.3
59	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	24.7
60	15.0	21.3	25.0	25.0	8.0	24.7	25.0	25.0	25.0	0.0
61	15.0	19.7	**20.7**	23.0	20.7	18.3	***22.3***	*25.0*	22.3	***25.0***
62	25.0	25.0	25.0	25.0	16.7	25.0	25.0	25.0	25.0	16.7
63	15.0	**23.3**	25.0	25.0	9.0	25.0	25.0	25.0	25.0	0.0

Note: Italics mean the person was a single during the voting round; bold indicates an exogenous group.

ID	VP 1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9	VP 10
64	21.7	21.7	21.7	20.0	14.3	21.7	**21.0**	**21.7**	**21.0**	**18.3**
65	19.7	20.7	22.0	23.7	24.0	21.7	**25.0**	25.0	24.7	25.0
66	6.0	**5.0**	**5.0**	**16.7**	21.7	21.7	18.3	**23.3**	**23.3**	7.0
67	11.3	23.3	25.0	23.3	25.0	24.0	25.0	25.0	25.0	16.7
68	6.0	**7.0**	**10.7**	**11.0**	15.0	22.3	**20.0**	**25.0**	25.0	16.7
69	17.7	19.0	19.7	19.7	***6.7***	19.0	**23.3**	19.7	**20.0**	0.0
70	16.7	**12.7**	**2.0**	**10.0**	23.3	21.0	**25.0**	25.0	8.3	**0.0**
71	18.3	23.3	25.0	24.0	25.0	24.3	25.0	25.0	25.0	25.0
72	22.7	25.0	25.0	25.0	25.0	23.3	16.7	**25.0**	25.0	25.0
73	4.7	***15.3***	***21.7***	***23.3***	16.7	16.0	**21.3**	**23.0**	22.3	23.0
74	20.0	20.0	22.0	24.0	20.0	23.0	24.3	25.0	25.0	19.7
75	20.0	23.3	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
76	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	0.0
77	21.7	18.3	21.7	21.7	20.0	18.3	**20.0**	**21.7**	**20.0**	6.7
78	25.0	25.0	24.0	23.7	***0.0***	25.0	25.0	25.0	25.0	16.7
79	10.3	19.3	25.0	25.0	25.0	24.3	24.3	25.0	21.7	**21.7**
80	24.7	21.7	22.0	24.0	24.3	22.7	24.7	24.3	24.7	24.3
81	23.3	25.0	24.7	25.0	25.0	24.7	24.3	25.0	24.7	25.0
82	11.7	**25.0**	18.3	**25.0**	24.3	20.0	20.0	21.7	25.0	16.7
83	19.0	20.3	18.3	**22.3**	24.0	24.0	21.3	22.7	23.3	23.0
84	20.0	25.0	24.3	24.7	16.7	22.0	25.0	25.0	25.0	16.7
85	21.0	20.0	24.3	23.7	23.3	21.7	25.0	22.7	23.3	15.0
86	25.0	25.0	25.0	25.0	25.0	25.0	21.7	**16.7**	**25.0**	**18.3**
87	13.3	**18.3**	*24.0*	18.3	**20.0**	18.3	**15.0**	**7.0**	**18.3**	**10.0**
88	20.0	21.3	22.7	23.7	17.3	22.0	23.0	23.3	23.3	11.7
89	15.0	23.0	23.7	25.0	0.0	22.3	25.0	24.0	24.7	**0.0**
90	22.7	25.0	25.0	24.7	**24.0**	25.0	25.0	25.0	22.0	**6.7**

91	14.0	15.3	**17.0**	15.0	**16.7**	13.0	***22.3***	17.3	**15.7**	**10.0**
92	5.7	**19.0**	21.7	18.3	**19.3**	19.0	16.7	21.3	**15.0**	**11.7**
93	16.7	14.0	**17.7**	11.3	**13.3**	13.7	**8.7**	**1.0**	**20.0**	**15.7**
94	21.7	23.3	23.3	23.3	0.0	20.7	25.0	***25.0***	24.3	0.0
95	9.3	17.7	20.3	21.7	8.3	20.0	25.0	25.0	25.0	25.0
96	11.7	17.0	18.7	20.0	21.0	20.0	19.7	**24.0**	17.7	**13.0**
97	25.0	23.3	20.0	21.7	15.0	24.3	22.0	22.3	21.7	0.0
98	10.0	16.7	20.0	22.0	5.0	21.0	23.0	22.0	0.0	**0.0**
99	8.3	**20.0**	23.3	23.3	13.3	21.7	25.0	21.7	23.3	**23.3**
100	12.3	**9.7**	**14.3**	**16.3**	10.0	19.7	**24.3**	24.0	**15.0**	12.3
101	10.7	**13.3**	**20.0**	**14.0**	**19.7**	19.7	**20.0**	***25.0***	20.0	21.0
102	25.0	25.0	25.0	24.7	25.0	24.3	**16.7**	**16.7**	**25.0**	16.7
103	21.7	23.3	24.3	25.0	25.0	25.0	25.0	25.0	25.0	20.0
104	16.7	20.7	23.3	24.3	25.0	16.7	**18.3**	21.7	15.0	15.0
105	11.7	**21.7**	25.0	21.7	25.0	25.0	25.0	25.0	25.0	20.0
106	16.7	**16.0**	15.3	**15.0**	**18.0**	23.7	25.0	25.0	25.0	16.7
107	8.7	**17.3**	**14.7**	**16.7**	**19.3**	25.0	25.0	25.0	25.0	25.0
108	20.3	20.7	22.3	**18.7**	**18.0**	25.0	25.0	24.7	17.3	**22.3**
109	14.0	12.7	**23.3**	**20.0**	**13.3**	25.0	25.0	25.0	25.0	16.7
110	10.0	14.7	**17.3**	**19.0**	**17.7**	15.7	**20.0**	21.0	21.7	**14.3**
111	21.7	25.0	25.0	25.0	16.7	23.3	**23.3**	25.0	25.0	11.7
112	25.0	25.0	25.0	25.0	8.3	25.0	25.0	25.0	25.0	8.3
113	21.7	**25.0**	25.0	25.0	8.3	25.0	25.0	25.0	25.0	16.7
114	23.3	25.0	25.0	25.0	16.7	25.0	25.0	25.0	21.7	11.7
115	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	**16.7**	**25.0**
116	15.0	**21.7**	21.7	16.7	**15.3**	17.3	**15.0**	18.7	**16.7**	**22.0**
117	16.0	**21.7**	25.0	25.0	16.7	13.3	**15.0**	**13.3**	**10.0**	**5.0**

Note: Italics mean the person was a single during the voting round; bold indicates an exogenous group.

Appendix E

Figure E1: Average contributions and profits in Main treatment, by individual

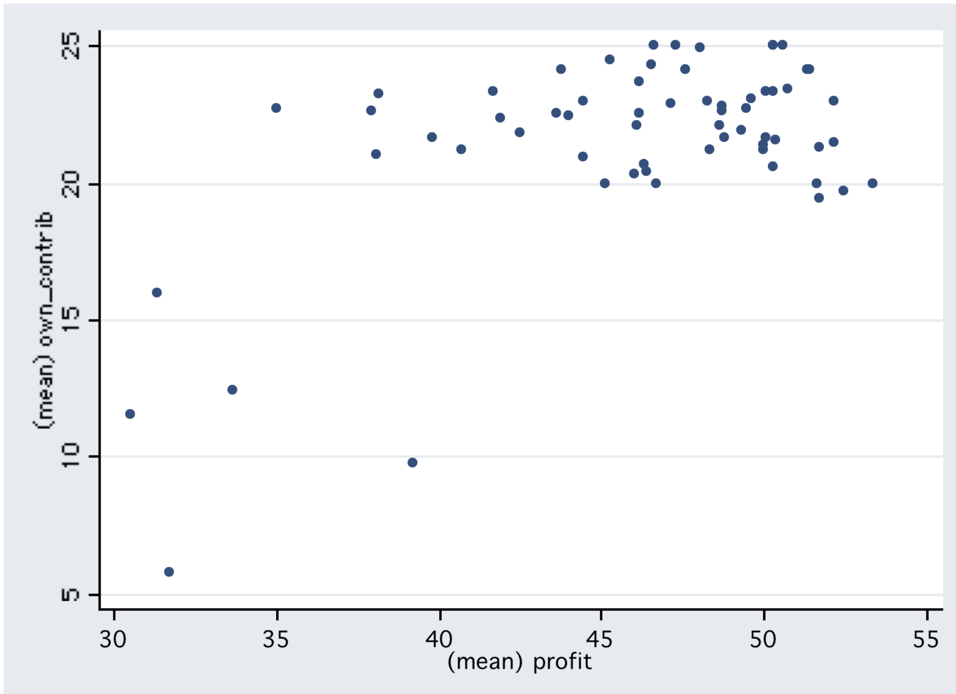

Figure E2: Average contributions and profits in Truncated treatment, by individual