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Effects of Framing, Group Size, and the Contribution Mechanism on Cooperation in Threshold Public Goods and Common Resources Experiments

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ABSTRACT

This paper examines cooperation in threshold public goods and common resources games by considering different sizes of groups and contribution mechanisms. Our experimental findings show first that framing has no significant main effect on cooperation, while its interaction with group sizes is significant. More specifically, subjects in small groups preferred giving to not-taking and preferred taking-all to giving-nothing, while subjects in large groups by contrast preferred just the opposite. This indicates that subjects acted more aggressively in small groups, while in large groups they behaved rather passively. Secondly, the continuous contribution mechanism greatly alleviated the incentive to completely free ride in both small and large groups, regardless of the frame. Finally, providing public goods and common resources in small groups was the most effective way of achieving the Pareto efficient outcome and maximizing social welfare.

1. INTRODUCTION

The idea of decision framing, which originated from the Prospect Theory developed by Kahneman and Tversky (1979, 1982, 1984) and Tversky and Kahneman (1981), states that decisions yielding the same outcome or objective may not be regarded as psychologically equivalent. Individuals' preferences or choices may be influenced by the way in which a decision is initially framed. These arguments have been constantly tested in relation to several economic issues, for instance, the public goods/common resources dilemma, preference reversals, and the disparity between willingness to pay and willingness to accept.[1] These issues are of particular interest because economic theories usually predict the same conclusion regardless of the frame, while experimental evidence often gives rise to differences, despite the potential outcomes for different frames being identical.

In this paper we shall explore the public goods/common resources dilemma. This dilemma has been examined in various frameworks and the results are generally inconsistent. Most experimental studies that examined this dilemma instructed subjects to "give some" in the public goods experiments and to "take some" in the common resources experiments.[2] Of the studies conducted, some found higher levels of cooperation in public goods experiments than in common resources experiments, some found just the opposite, and some found there to be no differences between these two frames.

Aquino, Steisel, and Kay (1992) specifically examined the public goods/common resources dilemma using a step-level mechanism in which public goods or common resources were provided only if group contributions exceeded a certain threshold. In each frame, subjects were divided into groups of four and played two games with different resource distributions. Decisions regarding giving and taking were discrete, with increments of $1000. Subjects made only one decision in each game, but without knowing it in advance. No framing effect was found in the work of Aquino et al. (1992).

Sonnemans, Schram, and Offerman (1998) also tested the public goods/common

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[1] See surveys by Davis and Holt (1993) and Kagel and Roth (1995) for details.

[2] An exception is Andreoni (1995), who examined the puzzle of public goods and common resources by using an externality framework.

resources dilemma with a step-level mechanism. Subjects were randomly assigned to groups of five and played twenty rounds of the threshold public goods/common resources game. They could only choose to give to the public good (or take from the common resource) or not. Sonnemans, Schram, and Offerman (1998) found that subjects in public goods experiments were significantly more cooperative than subjects in common resources experiments.

Rutte, Wilke, and Messick (1987) and van Dijk and Wilke (1995) also examined the public goods/common resources dilemma in a threshold setting, but allowed for continuous contributions. In Rutte, Wilke, and Messick (1987), subjects were assigned to groups of five or six and played only one shot. No framing effect was found, and therefore Rutte, Wilke, and Messick concluded that the framing effect might only hold under conditions in which subjects faced a sequence of decisions. Van Dijk and Wilke (1995) conducted one-shot experiments by using a group size of four, but in a slightly different environment in which group members were assigned asymmetric endowments and asymmetric interests. They found that subjects playing a public goods game tended to give in proportion to their endowments or interest position, and that subjects playing a common resources game coordinated their behavior to minimize the difference in final outcomes.

Differing from the above studies of threshold public goods/common resources games, Brewer and Kramer (1986), Fleishman (1988), and van Dijk and Wilke (1997) adopted a continuous contribution mechanism and imposed no threshold. Brewer and Kramer (1986) manipulated the experiments in two group sizes, eight and thirty-two, and assumed that the public goods and common resources increased by a replenishment factor of between 1% and 10% and allowed for only continuous contributions. They found that subjects in public goods experiments were less cooperative than subjects in common resources experiments. In addition, in public goods experiments subjects were less cooperative in larger groups, while in common resources experiments no group size effect was found.

In Fleishman (1988), subjects in groups of four or five made a series of one to nine decisions, but they were not told the exact numbers of trials in the series. Here, Fleishman found instead no framing effect. Van Dijk and Wilke (1997) used a group size of four and investigated the dilemma of public goods and common resources in a different vein by framing the initial property in a partitioned or a collective way in each frame. They found in the common-resource frame that subjects in the Partitioned Property conditions were less cooperative than subjects in the Collective Property conditions, but property treatment had no effect on cooperation in the public-good frame.

Based on the experimental studies referred to above, it can be seen that some tested the dilemma of public goods and common resources for only one shot, some tested it repeatedly over ten or twenty rounds, while some tested it in a dynamic framework in which the public good or the common resource could be replenished. In addition to the diversity in the number of rounds played, whether or not a threshold was imposed and whether or not subjects were instructed to give or take in a binary or a continuous manner also differed among the above-mentioned studies. Furthermore, group sizes varied, too. Except for Brewer and Kramer (1986) who also examined the group size effect, all of the other studies allowed for only small sizes of groups. Due to all of these disparities, there was hardly a basis for comparing these experimental results from various studies.

This paper examines the framing effect by focusing on a threshold framework. The threshold case differs from the no-threshold case in that being pivotal or not will affect one's incentive to cooperate. In addition, in the no-threshold case with a simple linear public goods design,[3] complete free-riding is the unique dominant-strategy Nash equilibrium. By contrast, so long as a threshold is imposed, there exist multiple Nash equilibria, including everyone contributing nothing and the sum of contributions exactly matching the threshold. None of these equilibria remains a dominant-strategy equilibrium.

In our experimental design, both the public-good frame and the common-resource frame were examined for groups of five and groups of twenty, and each group size was accompanied by both the binary and continuous contribution mechanisms. We adopted this design because we conjecture that one can more easily become pivotal in a small group than in a large group, and an all-or-nothing decision enhances one's pivotal position. Furthermore, providing public goods/common resources in small groups rather than large groups help the group focus on the threshold and therefore lift cooperation. Similarly, the continuous contribution mechanism allows symmetric contributions and helps the group to split the threshold evenly among group members. As a consequence, group size and the contribution mechanism may interact with decision framing, and thereby different framing effects may be observed for different sizes of groups and contribution mechanisms.

The rest of the paper is organized as follows. Section 2 presents the models of

[3] The linear public goods design was first introduced by Marwell and Ames (1981) and has been adopted by many subsequent researchers.

threshold public goods and common resources games and briefly characterizes the Nash equilibria. Section 3 describes the experimental design, and Section 4 presents the experimental results. Conclusions and policy implications are provided in Section 5.

2. NASH EQUILIBRIA IN THRESHOLD PUBLIC GOODS AND COMMON RESOURCES GAMES

The models of threshold public goods games have been developed by Palfrey and Rosenthal (1984), Bagnoli and Lipman (1989), and Cadsby and Maynes (1999), and have been tested experimentally by van de Kragt, Orbell, and Dawes (1983), Isaac, Walker, and Thomas (1984), Issac, Schmidtz, and Walker (1989), Bagnoli and McKee (1991), Marks and Croson (1998), and Cadsby and Maynes (1999). In addition, Andreoni (1998) has presented a model of fund-raising which in some respects were similar to the models above. In this paper, we use the models of threshold public goods games developed by Cadsby and Mayne (1999), and then switch them to models of threshold common resources games.

It is assumed in our models and experimental designs that there is no refund if group contributions fail to meet the threshold, and any excess contributions will simply be wasted.[4] Individuals are each endowed with wealth w and allocate that wealth between consumption of the private good, x_i, and donations to the public good, g_i. Note that g_i is either 0 or w under the binary contribution mechanism. In the threshold public goods game, the public good G will be provided if and only if group contributions reach or exceed a certain threshold, T. It is assumed that T is a multiple of w to avoid unnecessary wastage. We denote n as the group size and $\sum_{i=1}^{n} g_i$ as the total gifts donated by all group members. The level of the public good is therefore

$$G = \begin{cases} T, & \text{if } \sum\limits_{i=1}^{n} g_i \geq T, \\ 0, & \text{if } \sum\limits_{i=1}^{n} g_i < T. \end{cases}$$

[4] These assumptions were used in the experiments that imposed the threshold cited in Section 1. A series of experiments that focus on the effects of the motivations of greed and fear on defection in particular consider the assumption that there is a refund. See, for instance, Ahn, Ostrom, Schmidt, Shupp, and Walker (2001), Dawes, Orbell, Simmons, and van de Kragt (1986), Poppe and Utens (1986), Poppe and Zwikker (1996), and Rapoport and Levy (1989).

Individuals' preferences are represented by the utility function $u_i(x_i, G) = x_i + B$, where B represents the benefits from consuming the public good. It is assumed in the experimental design that $B = a(T/nw)$ if the public good is provided. In other words, if a minimum fraction of group wealth, T/nw, is donated to the public good, then each group member will earn a bonus which is a multiple of a of this fraction. Otherwise, G is not provided and thus $B = 0$. Note that the parameter a must satisfy the condition $a > (nw/T)w$ to make $B > w$ if group contributions reach the threshold. Note also that the condition $w < T < nw$ is required such that individuals have incentives to contribute and to free ride.

With the binary contribution mechanism, each individual decides between contributing and not contributing so as to maximize his (her) utility. It is obvious that an individual will contribute if and only if he or she is pivotal, that is, $g_i = w$ if and only if $T - \sum_{j \neq i} g_j = w$. The Nash equilibria in this threshold public goods game, as solved by Cadsby and Maynes (1999), are as follows. First, we have a complete free-riding Nash equilibrium in which no one contributes, since the best response to $\sum_{j \neq i} g_j = 0$ is $g_i = 0$ for all i. It then follows that $G = 0$. Second, we have some asymmetric pure-strategy Nash equilibria in which $\sum_{j \in C} g_j = T$, where C is the set of contributors. If $i \in C$, then the best strategy for i is to remain a contributor. On the contrary, if $i \notin C$, then the best strategy for i is to back out. Third and finally, we have an infinite number of mixed-strategy Nash equilibria in which individuals randomize the probabilities of contributing and not contributing such that the sum of each individual's expected contributions exactly meets T. Following Cadsby and Maynes (1999), we call the Nash equilibria in the latter two cases the threshold Nash equilibria, since in these equilibria group contributions precisely match the threshold.

The above threshold public goods game can easily be transformed into a threshold common resources game. Let us now call G the common resource and denote $\overline{G}$ as the initial size of it. Individuals are each endowed with nothing, but instead an entitlement to exploit the common resource. Let us denote the entitlement as w and assume that w satisfies $nw = \overline{G}$. The amount that individual i exploits from the common resource will be his (her) consumption of the private good x_i, which is either 0 or w when exploitations are binary. The amount that individual i leaves in the common resource is thus $g_i = w - x_i$ and the total amount of leftover is $\sum_i g_i = \overline{G} - \sum_i x_i$. If total exploitation, $\sum_i x_i$, exceeds a certain threshold $\overline{T}$, or in other words, if the total amount of leftover, $\sum_i g_i$, drops below $T = \overline{G} - \overline{T}$, then the common resource is gone. Otherwise, the common resource remains and is equal to $T = \overline{G} - \overline{T}$. That is,

$$G = \begin{cases} \overline{G} - \overline{T}, & \text{if } \sum_{i=1}^{n} x_i \leq \overline{T}, \\ 0, & \text{if } \sum_{i=1}^{n} x_i > \overline{T}. \end{cases}$$

The individual behaves in such a way so as to maximize the same utility function $u_i(x_i, G) = x_i + B$ as in the case of the public goods game, but chooses x_i instead of g_i. Note that the condition $\overline{G} - w > \overline{T} > 0$ (which is equivalent to the condition $w < T < nw$ in the public goods game) must be imposed so that individuals have incentives not to exploit and to free ride.

We can see that the threshold common resources game is identical to the threshold public goods game. In the threshold common resources game with binary contributions (or more properly, exploitations), the individual will exploit the common resource if and only if (s)he is not pivotal, that is, $x_i = w$ if and only if $\sum_{j \neq i} x_j \neq \overline{T}$ and $x_i = 0$ otherwise. The Nash equilibria in the threshold common resources game are simply analogous to those in the threshold public goods game. Specifically, we have first a complete free-riding Nash equilibrium in which $x_i = w$ for all i, since the best response to $\sum_{j \neq i} x_j = \overline{G} - w$ is $x_i = w$ for all i. Second, we have many asymmetric pure-strategy Nash equilibria in which $\sum_{j \in E} x_j = \overline{T}$, where E is the set of exploiters. In this case, if $i \in E$, then the best strategy for i is to remain a taker. If $i \in E$, then the best strategy for i is to leave his or her total entitlement there. Third and lastly, we have an infinite number of mixed-strategy Nash equilibria in which individuals randomize the probabilities of exploiting and not exploiting such that the sum of the expected amounts taken by all group members is exactly equal to $\overline{T}$.

If contributions are continuous, i.e., $g_i \in [0, w]$, then it is less apparent to define the "pivotal" agent. Any shortage below the threshold can be made up by more than one group member, and it is possible for more than one contributor to withdraw any proportion of their current contributions if group contributions exceed the threshold. The Nash equilibria in the case of the threshold public goods game with continuous contributions, which were also solved by Cadsby and Maynes (1999), include the following. First of all, there is a complete free-riding Nash equilibrium in which everyone contributes zero as long as $w < T$, since the best response to $\sum_{j \neq i} g_j = 0$ is $g_i = 0$ for all i. Second, we have a symmetric pure-strategy Nash equilibrium in which every group member contributes $g_i = T/n$ if $T/n < w$ and $B > T/n$. Third, there is an infinite number of asymmetric pure-strategy Nash equilibria in which group contributions satisfy $\sum_j g_j = T$. Fourth and finally, we have an infinite number of mixed-strategy Nash equilibria in which individuals randomize the probabilities of all possible amounts of contributions such that the sum of the expected contributions made by all group members exactly matches the threshold T.

We can also easily transform the above threshold public goods game into a threshold common resources game by letting $\overline{G}$ be the initial size of the common source and $x_i \in [0, w]$ be individual i's exploitation of the common resource. The Nash equilibria in the common resources game are analogous. Put briefly, we have first a complete free-riding Nash equilibrium in which $x_i = w$ for all i. Another symmetric pure-strategy Nash equilibrium is illustrated by $x_i = \overline{T}/n$ for all i. Third, there is also an infinite number of asymmetric pure-strategy Nash equilibria in which $\sum_j x_j = \overline{T}$. Finally, we have an infinite number of asymmetric mixed-strategy Nash equilibria in which group members randomize the probabilities of exploiting various amounts of the common resource such that the sum of the expected amounts exploited by all group members is exactly equal to $\overline{T}$.

Notice that theoretically, group sizes have no effect on cooperation if the same minimum fraction of group wealth allocated to the public good (T/nw) is imposed in various sizes of groups. Notice also that the threshold Nash equilibria are Pareto efficient, and that the threshold Nash equilibria are the only equilibria satisfying Pareto efficiency. Furthermore, any equilibrium in which group contributions reach the threshold improves upon any equilibrium in which group contributions fall short of the threshold.

3. EXPERIMENTAL DESIGN

We conducted two series of experiments, each involving two frames: the public-good frame and the common-resource frame. In one series of experiments, subjects were instructed to give to the public good or take from the common resource in a binary manner, while in the other series of experiments giving and taking were continuous. Both public-good and common-resource frames were each played in groups of five and twenty, and on this basis four experiments were involved in each series of experiments. Sixty subjects were used in each experiment involving the twenty-person groups and 50 subjects were used in each experiment involving the five-person groups, except in the common resources experiment with binary contributions, in which only 45 subjects showed up. Therefore, a total of 435 subjects participated in this study.

The subjects were undergraduate students at National Chengchi University and National Taiwan University. All subjects were inexperienced. Among them, 163 were males and 272 were females, and 369 of the subjects majored in economics or economics-related fields. The mean age was 20.38 years and average earnings were NT$312.[5]

Subjects' Instructions, Earnings Reports, and Decision Forms were handed out to each subject after (s)he was seated.[6] The subjects in each experiment played ten decision rounds and were randomly assigned their group numbers. They were aware that group numbers remained unchanged over all ten rounds, but did not know to which group they belonged. Except for the group numbers that were assigned to all subjects, all other parameters in the experiment [including group size, the endowment and group contributions (in public goods experiments), the maximum exploitation and group leftovers (in common resources experiments), and the payoff scheme] were public information. We used $T/nw = 3/5$ and $a = 500$ in all of the experiments, namely, if at least three-fifths of group wealth was allocated to the public good (common resource), then each group member would receive a bonus $B = a(T/nw) = 300$. Otherwise, the public good (common resource) was not provided and $B = 0$.

In the threshold public goods experiments with binary contributions, subjects were each endowed with 100 points per round. They were instructed to invest either 0 or 100 points to the Public Account. Points not invested in the Public Account would be retained in the subject's own Private Account, and one point in the Private Account would earn the subject one point. In the experiment involving the five-person groups, if three or more than three group members gave 100 points to the Public Account, then each group member would receive a bonus of 300 points. However, if fewer than three group members gave to the Public Account, then none of the group members would receive a bonus and all points invested in the Public Account would be wasted. The subject's earnings per round comprised the sum of the return from his (her) Private Account and the bonus from the Public Account.

The same minimum fraction of group wealth allocated to the Public Account and the same award were adopted in the experiment involving the twenty-person groups.

[5] It took about 80 minutes to finish one experiment, and on that basis average hourly earnings per subject were about NT$234, more than twice the part-time hourly wage rate for an undergraduate student in Taiwan. The exchange rate between the NT (New Taiwan) dollar and the U.S. dollar was about 33:1 when these experiments were conducted. Data from experiments are available from the author upon request.

[6] Subjects' Instructions, Earnings Reports, and Decision Forms are available from the author upon request.

Specifically, if twelve or more than twelve group members gave 100 points to the Public Account, then each group member would receive a bonus of 300 points, otherwise, no one would receive any bonus.

In the threshold common resources experiments with binary contributions, each subject was endowed with zero points and was instructed to take either 0 or 100 points from the Public Account. Points withdrawn from the Public Account would be invested in the subject's own Private Account, and one point in the Private Account would earn the subject a return of one point. In the experiment involving the five-person groups, 500 points were initially invested in the Public Account. If two or less than two group members took from the Public Account, then each group member would receive a bonus of 300 points. However, if more than two group members took from the Public Account, then no bonus would be earned, and all points left in the Public Account would be wasted.

In the experiment involving the twenty-person groups, 2,000 points were likewise initially invested in the Public Account. If eight or less than eight group members took from the Public Account, then each group member would receive a bonus of 300 points. Otherwise, the Public Account would be gone and all points left in this account would be wasted.

In experiments with continuous contributions, subjects in the public-good frame were instructed to give any points between 0 and 100 to the Public Account, while subjects in the common-resource frame were instructed to take any points between 0 and 100 from the Public Account. In the threshold public goods experiment involving the five-person groups, if group contributions reached or exceeded 300 points, then each group member would receive a bonus of 300 points. In the threshold common resources experiment involving the same group size, if the total amount of leftover in the Public Account remained at least 300 points, then each group member would receive a bonus of 300 points. Similarly, in the experiments involving the twenty-person groups, each group member would receive the same reward of 300 points if the threshold of 1,200 points was reached (in the public goods experiment) or was maintained (in the common resources experiment).

4. EXPERIMENTAL RESULTS

Tables 1–5 report the experimental evidence. We perform the statistical analyses by employing a $2 \times 2 \times 2$ (public-good frame vs. common-resource frame by group size of five vs. group size of twenty by binary contributions vs. continuous contributions) ANOVA (analysis of variance) and illustrate the statistical results in Table 6. The main findings from the experiments are summarized in a series of nine observations that in particular focus on cooperation and the incentives of complete free-riding. Observations 1–3 summarize the effects of framing, group size, and the contribution mechanism on cooperation, respectively. Observations 4–6 then correspondingly sketch the effects of these three factors on the incentives to completely free ride. Observations 7–9 present the results associated with the threshold Nash equilibria, the provision of public goods/common resources, and welfare levels.

4.1 The effects of framing, group size, and the contribution mechanism on cooperation

Table 1 reports the cooperation rate per round in various experiments. The notation B-PG-5 refers to the threshold public goods experiment involving the five-person groups with binary contributions. The notations for other experiments may be explained analogously. The cooperation rate in the public-good frame is defined as the total number of points allocated to the Public Account divided by total endowments, and in the common-resource frame it is defined as the total number of points left in the Public Account divided by the initial size of the Public Account.

Notice first of all that the results from the B-PG-5 and B-COM-5 are very similar to those found in Sonnemans, Schram, and Offerman (1998). Sonnemans, Schram, and Offerman found that the overall cooperation in the public-goods frame was 51.1% and in the common-resource frame it was 39.9%. These figures are very close to the cooperation rates of 51.4% and 41.1% found in this paper. Furthermore, except in B-PG-20 and B-COM-20, the average cooperation rates in all other experiments were above 40%, showing fairly high cooperation. Even in B-PG-20 and B-COM-20, average cooperation rates were still around 30%. Finally, cooperation across all ten rounds was quite smooth in all experiments except in B-PG-20 and B-COM-20. In B-PG-20, the cooperation rate started as high as 40%, and then suddenly dropped to 18.33% in round three. Though the cooperation rate then rose steadily to 36.67% in round eight, it dropped abruptly again to 16.67% in round ten. The cooperation rate changed more drastically in B-COM-20: it started at 23.33%, rose to 60% in round six, and then fell sharply to 21.67% at the end.

We shall now study the effect of framing on cooperation. The ANOVA results in

Table 1 Cooperation Rate per Round (in%)

	Round										
Experiment	1	2	3	4	5	6	7	8	9	10	All
B-PG-5	46.00	60.00	54.00	46.00	48.00	56.00	58.00	52.00	50.00	44.00	51.40
B-COM-5	37.78	48.89	51.11	40.00	35.56	37.78	46.67	42.22	37.78	33.33	41.11
B-PG-20	40.00	33.33	18.33	21.67	23.33	26.67	30.00	36.67	28.33	16.67	27.50
B-COM-20	23.33	26.67	28.33	25.00	40.00	60.00	55.00	38.33	36.67	21.67	35.50
C-PG-5	48.50	53.20	56.12	58.30	59.30	54.92	55.92	53.44	56.12	46.74	54.26
C-COM-5	49.76	50.90	51.10	42.06	40.60	39.40	41.40	42.00	37.10	30.60	42.49
C-PG-20	47.42	43.42	42.50	40.17	40.08	45.67	48.08	46.00	46.50	51.33	45.12
C-COM-20	55.65	55.10	54.42	53.35	55.45	57.22	54.30	49.35	49.55	42.23	52.66

column 2 of Table 6 show that framing has no main effect on cooperation. The difference between cooperation in the public-good frame $(M = 44.57\%)$ and cooperation in the common-resource frame $(M = 42.94\%)$ is insignificant $(F(1, 72) = 1.078,\ p = 0.3026)$. Though we find no main effect of framing on cooperation, the interaction between framing and group size is significant $(F(1, 72) = 35.986,\ p < 0.0001)$. We therefore decompose the three factors (framing, group size, and the contribution mechanism) to determine which ones differ significantly. We find that in groups of five with binary contributions, subjects in the public-good frame were significantly more cooperative than subjects in the common-resource frame $(F(1, 18) = 10.78,\ p = 0.002)$. This result is consistent with that of Sonnemans, Schram, and Offerman (1998). Cooperation was still significantly higher in the public-good frame than in the common-resource frame $(F(1, 18) = 14.09,\ p < 0.001)$ under the continuous contribution mechanism if group size remained at five. However, as the group size increased to twenty, cooperation was instead significantly higher in the common-resource frame than in the public-good frame under both the binary $(F(1, 18) = 6.52,\ p = 0.013)$ and continuous contribution mechanisms $(F(1, 18) = 5.8,\ p = 0.019)$. Observation 1 summarizes these findings as follows:

Observation 1 Framing has no main effect on cooperation, while the interaction with group size is significant. Specifically, in groups of five cooperation was higher in the public-good frame than in the common-resource frame when the group size was five, whereas in groups of twenty cooperation was higher in the common-resource frame than in the public-good frame, regardless of the contribution mechanisms.

Observation 1 suggests that subjects in groups of different sizes behaved differently. Subjects in small groups preferred actively giving to passively not-taking, while subjects in large groups instead preferred not-taking to giving, regardless of whether or not giving and taking were in an all-or-nothing or a continuous manner.

We then look at how group size affects cooperation. The ANOVA results of column 2 in Table 6 exhibit a significant main effect of group size: subjects in groups of five $(M = 47.32\%)$ were significantly more cooperative than subjects in groups of twenty $(M = 40.20\%; F(1, 72) = 20.65,\ p < 0.0001)$. Furthermore, the interaction effects between group size and framing $(F(1, 72) = 35.986,\ p < 0.0001)$ and group size and the contribution mechanism $(F(1, 72) = 23.746,\ p < 0.0001)$ are also significant. Observation 2 illustrates these results:

Observation 2 On average, subjects in groups of five were more cooperative than subjects in groups of twenty, and this main effect of group size is qualified by the significant interactions between group size and framing and between group size and the contribution mechanism.

We finally examine the effect of the contribution mechanisms on cooperation. The ANOVA results show that the main effect is significant: subjects in experiments with continuous contributions $(M = 48.63\%)$ were more cooperative than subjects in experiments with binary contributions $(M = 38.88\%; F(1, 72) = 38.75,\ p < 0.0001)$. Furthermore, as indicated above, there exists a significant interaction between the contribution mechanism and group size, while the interaction between the contribution mechanism and framing is insignificant $(F(1, 72) = 0.095,\ p = 0.759)$. Therefore, the effect of the contribution mechanisms on cooperation relies on the main effect of the contribution mechanisms as well as the interaction with group sizes, but not frames. Further investigation shows that cooperation was higher under the continuous contribution mechanism than under the binary contribution mechanism when the group size was twenty, while no difference between these two mechanisms was found to exist when the group size was five, regardless of the frame.[7] We therefore state Observation

[7] For groups of five, cooperation under the continuous contribution mechanism did not differ significantly from cooperation under the binary contribution mechanism, in both the public-good frame $(F(1, 18) = 0.83,\ p = 0.365)$ and the common-resource frame $(F(1, 18) = 0.19,\ p = 0.661)$. For groups of twenty, cooperation was significantly higher under the continuous contribution mechanism than under the binary contribution mechanism, in both the public-good frame $(F(1, 18) = 31.6,\ p < 0.0001)$

3 below:

Observation 3 Continuous contributions significantly raised cooperation in groups of twenty, regardless of the frame.

Observation 2 suggests that cooperation was higher in small groups than in large groups, regardless of the contribution method adopted. This result may be attributable to subjects' perceptions that they were more pivotal in small groups than in large groups, and being pivotal induced more contributions since contributions would be less likely to be wasted. Of course, if subjects turned out to be less pivotal, then wastage would be larger with binary contributions than with continuous contributions. In a way that is quite consistent with Observation 2, Observation 3 suggests that subjects were more willing to cooperate if they could take or give in a continuous manner instead of a binary way, but only when they were in large groups.

Observation 3 can be regarded as a complementary result to the finding in Cadsby and Maynes (1999). In threshold public goods experiments involving the ten-person groups, they found that permitting continuous rather than binary contributions significantly raised contributions. Since the group size used in their study was somewhere between the group sizes used in this paper, we may conjecture, at least in relation to the provision of public goods, that the contribution mechanisms have no effect on cooperation in small groups. However, permitting continuous contributions rather than binary contributions induces more contributions as the size of the groups increases to a certain level.

4.2 The effects of framing, group size, and the contribution mechanism on complete free-riding incentives

It may be interesting to ask how often subjects adopted the complete free-riding strategy. We begin by examining the effect of framing on the incentive to completely free ride. As shown in Table 2, complete free-riding in all ten rounds was higher in B-COM-5 than in B-PG-5 and the difference was more salient between C-COM-5 and C-PG-5. As the group size increased to twenty, subjects in B-COM-20 completely free rode more than subjects in B-PG-20 in only the first two rounds, and then the reverse trend occurred starting with round three. When the contributions were continuous, complete free riding was also higher in C-PG-20 than in C-COM-20 except in the final round.

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and the common-resource frame $(F(1, 18) = 29.99,\ p < 0.0001)$.

Table 2 Percentage of Subjects Contributing Zero to the Public Account

	Round										
Experiment	1	2	3	4	5	6	7	8	9	10	All
B-PG-5	54.00	40.00	46.00	54.00	52.00	44.00	42.00	48.00	50.00	56.00	48.60
B-COM-5	62.22	51.11	48.89	60.00	64.44	62.22	53.33	57.78	62.22	66.67	58.89
B-PG-20	60.00	66.67	81.67	78.33	76.67	73.33	70.00	63.33	71.67	83.33	72.50
B-COM-20	76.67	73.33	71.67	75.00	60.00	40.00	45.00	61.67	63.33	78.33	64.50
C-PG-5	14.00	10.00	16.00	10.00	6.00	10.00	12.00	14.00	14.00	24.00	13.00
C-COM-5	20.00	20.00	24.00	32.00	38.00	40.00	40.00	36.00	44.00	54.00	34.80
C-PG-20	10.00	20.00	23.33	28.33	30.00	28.33	30.00	28.33	26.67	26.67	25.17
C-COM-20	3.33	6.67	13.33	15.00	8.33	11.67	18.33	23.33	20.00	26.67	14.67

The ANOVA results in column 3 of Table 6 indicate only a moderate main effect of framing: on average 43.22% of subjects in the common resources experiments took all from the Public Account, while on average 39.82% of subjects in the public goods experiments gave nothing to the Public Account $(F(1,72) = 3.425,\ p = 0.068)$. However, the main effect of framing was qualified by a salient interaction effect between framing and group size $(F(1,72) = 47.468,\ p < 0.0001)$. Further investigation shows that in groups of five with binary contributions, subjects in the common-resource frame completely free rode more than subjects in the public-good frame $(F(1,18) = 7.85,\ p = 0.007)$. Notice that this result can also be inferred from the effect of framing on cooperation in Subsection 4.1, since complete free-riding is simply the opposite of cooperation when contributions are binary. Complete free-riding was also significantly higher in the common-resource frame than in the public-good frame $(F(1,18) = 35.26,\ p < 0.0001)$ under the continuous contribution mechanism if group size remained at five. As group size increased to twenty, however, complete free-riding was instead significantly higher in the public-good frame than in the common-resource frame when contributions were binary $(F(1,18) = 4.75,\ p = 0.033)$ and when contributions were continuous $(F(1,18) = 8.18,\ p = 0.006)$. We illustrate these results in Observation 4:

Observation 4 Framing has no main effect on the incentive to completely free ride, while its interaction with group size is significant. Specifically, in groups of five complete free-riding was higher in the common-resource frame than in the public-good frame, while the opposite was found in groups of twenty, regardless of the contribution mechanism.

Observation 4 says that subjects in small groups were more willing to take all than to give nothing, while subjects in large groups preferred instead passive giving-nothing to the more aggressive taking-all, regardless of whether giving and taking were binary or continuous. We can see that Observation 4 is quite analogous to Observation 1. Combining these two observations indicates that subjects acted aggressively when they were in small groups, but they would instead behaved more gently if they were in large groups.

We now look at the effects of group size and the contribution mechanism on the incentive of complete free-riding. The ANOVA results in column 3 of Table 6 show a significant main effect of group size: subjects in groups of five $(M = 38.82\%)$ completely free rode less than subjects in groups of twenty $(M = 44.21\%; F(1, 72) = 8.609,\ p = 0.0045)$. This main effect is qualified by the interaction effects between group size and framing $(F(1, 72) = 47.468,\ p < 0.0001)$ and group size and the contribution mechanism $(F(1, 72) = 26.056,\ p < 0.0001)$. Finally, the ANOVA results show that the continuous contribution mechanism had the most salient effect in terms of alleviating the incentive to completely free ride: complete free-riding was significantly lower with continuous contributions $(M = 21.91\%)$ than with binary contributions $(M = 61.12\%; F(1, 72) = 456.358,\ p < 0.0001)$. Further examination shows that this effect held in both frames and in both contribution mechanisms.[8] We summarize these results in Observations 5 and 6.

Observation 5 On average, subjects in groups of five completely free rode less than subjects in groups of twenty, and this main effect of group size was qualified by the significant interactions between group size and framing and between group size and the contribution mechanism.

Observation 6 The continuous contribution mechanism substantially alleviated the incentive to completely free ride, in both group sizes and in both frames.

[8] In the public-good frame, complete free-riding was significantly lower with continuous contributions than with binary contributions in groups of five $(F(1, 18) = 94.03,\ p < 0.001)$ and in groups of twenty $(F(1, 18) = 166.23,\ p < 0.001)$. In the common-resource frame, complete free-riding was also significantly lower with continuous contributions than with binary contributions in groups of five $(F(1, 18) = 43.05,\ p < 0.001)$ and in groups of twenty $(F(1, 18) = 184.25,\ p < 0.001)$.

The literature of voluntary contribution mechanisms generally considers greed and fear as two main motivations for defection. We can see how greed and fear occur in a climate with a threshold. Greed takes place if one expects that sufficient contributions will be made by others and therefore there is no need for the subject to contribute. If instead (s)he expects that contributions made by others will be insufficient, then the motivation of fear will also prevent him/her from contributing.

Observation 5 suggests that the motivations of greed and fear are more intense in large groups than in small groups. As mentioned previously, subjects might perceive themselves as being more pivotal in small groups than in large groups. If this perception holds, then whether or not the motivations of greed and fear exist in small groups is ambiguous, since these two motivations will jeopardize successful provisions when a subject is pivotal. By contrast, an individual subject in large groups might account for his contributions as only a negligible share of total contributions (greed) or feel afraid of insufficient contributions (fear), and thereby choose not to contribute. However, as suggested by Observation 6, permitting continuous contributions rather than binary contributions can alleviate the motivations of greed and fear, even in large groups.

4.3 Threshold Nash Equilibria, Provision, and Welfare Levels

As introduced in Section 2, there are two types of Nash equilibria in the threshold public goods/common resources games. One is the complete free-riding Nash equilibrium and the other consists of threshold Nash equilibria, which are also Pareto efficient. Because the complete free-riding Nash equilibrium seldom occurs in all experiments, here we focus only on the threshold Nash equilibria.[9] As also discussed in Section 2, although the threshold Nash equilibria are the only equilibria satisfying Pareto efficiency, the equilibria in which group contributions exceed the threshold improve upon the equilibria in which group contributions fall short of the threshold. We therefore ask how often the public good/common resource is provided and report the level of social welfare in each experiment.

Table 3 reports the percentage of groups whose group contributions exactly matched the threshold. Observe first that threshold Nash equilibria were reached most frequently in B-PG-5 and B-COM-5. In B-PG-5 each group on average reached the threshold Nash equilibria 34% of the time, and in B-COM-5 this magnitude was 28.89%. The threshold Nash equilibria seldom occurred in the remaining experiments,

[9] The data are available from the author upon request.

Table 3 Percentage of Groups Matching the Threshold Nash Equilibria

	Round										
Experiment	1	2	3	4	5	6	7	8	9	10	All
B-PG-5	30.00	30.00	50.00	20.00	40.00	30.00	40.00	60.00	30.00	10.00	34.00
B-COM-5	11.11	44.44	33.33	22.22	33.33	22.22	33.33	44.44	33.33	11.11	28.89
B-PG-20	0.00	0.00	0.00	0.00	0.00	33.33	0.00	33.33	0.00	0.00	6.67
B-COM-20	0.00	0.00	0.00	0.00	0.00	33.33	33.33	33.33	0.00	0.00	10.00
C-PG-5	0.00	10.00	0.00	20.00	0.00	20.00	10.00	20.00	0.00	20.00	10.00
C-COM-5	10.00	0.00	0.00	30.00	40.00	10.00	20.00	30.00	30.00	30.00	20.00
C-PG-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00	3.33
C-COM-20	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33

especially in C-PG-20 and C-COM-20, in which the threshold Nash equilibria were reached only once by only one group.

We now examine the effects of framing, group size, and the contribution mechanism on the achievement of threshold Nash equilibria. The ANOVA results in column 4 of Table 6 report that group size and the contribution mechanism had significant main effects: the threshold Nash equilibria were reached significantly more often in groups of five $(M = 23.22\%)$ than in groups of twenty $(M = 5.83\%; F(1, 72) = 36.795,\ p < 0.0001)$, and the threshold Nash equilibria were achieved significantly more frequently under the binary contribution mechanism $(M = 19.89\%)$ than under the continuous contribution mechanism $(M = 9.17\%; F(1, 72) = 13.987,\ p = 0.0004)$. The interaction between group size and the contribution mechanism was also significant $(F(1, 72) = 3.984,\ p = 0.0497)$. By contrast, framing had neither a main effect nor interactions with group size or the contribution mechanism. We summarize these findings in Observation 7:

Observation 7 On average, threshold Nash equilibria were reached significantly more often in groups of five than in groups of twenty, and were reached significantly more often with binary contributions than with continuous contributions. Framing had no effect on reaching the threshold Nash equilibria.

Observation 7 suggests that large group sizes and a continuous contribution mech-

Table 4 Percentage of Groups Providing the Public Good/Common Resource

	Round										
Experiment	1	2	3	4	5	6	7	8	9	10	All
B-PG-5	40.00	70.00	70.00	40.00	50.00	50.00	60.00	70.00	50.00	30.00	53.00
B-COM-5	22.22	55.56	55.56	33.33	44.44	33.33	44.44	44.44	33.33	22.22	38.89
B-PG-20	0.00	0.00	0.00	0.00	0.00	33.33	0.00	33.33	0.00	0.00	6.67
B-COM-20	0.00	0.00	0.00	0.00	0.00	66.67	66.67	33.33	33.33	0.00	20.00
C-PG-5	10.00	40.00	60.00	50.00	50.00	50.00	60.00	60.00	70.00	40.00	49.00
C-COM-5	30.00	30.00	40.00	50.00	50.00	50.00	40.00	50.00	50.00	40.00	43.00
C-PG-20	0.00	0.00	0.00	0.00	33.33	33.33	66.67	33.33	66.67	33.33	26.67
C-COM-20	33.33	33.33	33.33	33.33	0.00	33.33	66.67	33.33	66.67	33.33	36.67

anism seemed to induce either unnecessary or insufficient contributions or both. Table 4, which reports the percentage of groups providing public goods/common resources, indeed verifies the fact that unnecessary contributions existed in most experiments. By comparing Table 4 with Table 3, we observe first that (except in B-PG-20) subjects in all other experiments contributed more than the threshold. Furthermore, continuous contributions seemed to induce more wasteful contributions than did binary contributions. With continuous contributions, on average 39% of groups made contributions to the public good that exceed the threshold in C-PG-5 and this magnitude was 23% in C-COM-5. Over-contribution remained above 20% even for groups of twenty: on average 23.33% of the groups in C-PG-20 and 33.33% of the groups in C-COM-20 over-contributed to the public good or the common resource. Under the binary contribution mechanism, by contrast, on average 19% of the groups contributed more than enough to the public good in B-PG-5. This number dropped to only 10% in B-COM-5 and B-COM-20, and contributions never exceeded the threshold in B-PG-20.

We shall now look at Table 4 specifically. Notice that public goods or common resources were quite often provided successfully for groups of five. On average, public goods were successfully provided about half of the time in B-PG-5 and C-PG-5, and common resources survived about 40% of the time in B-COM-5 and C-COM-5. Public goods or common resources were provided less frequently for groups of twenty, especially in B-PG-20, in which the public good was provided on only two occasions in all ten rounds.

The ANOVA results in column 5 of Table 6 indicate that both group size and the contribution mechanism had significant main effects: public goods and common resources were provided more successfully in groups of five $(M = 45.97\%)$ than in groups of twenty $(M = 22.50\%; F(1, 72) = 32.329,\ p < 0.0001)$, and were provided more successfully under the continuous contribution mechanism $(M = 38.84\%)$ than under the binary contribution mechanism $(M = 29.64\%; F(1, 72) = 4.961,\ p = 0.0291)$. The interaction between group size and the contribution mechanism was also significant $(F(1, 72) = 4.9,\ p = 0.03)$. By contrast, framing had no main effect, but it had a significant interaction in relation to group size $(F(1, 72) = 6.922,\ p = 0.0104)$. However, further examination showed that the frequencies of the successful provision of the public good did not differ significantly from those with regard to the common resource for both group sizes, under both the binary and continuous contribution mechanisms.[10] We therefore derive Observation 8 below:

Observation 8 Small group sizes and the continuous contribution mechanism helped provide public goods and common resources.

Observation 8 suggests that continuous contributions and small group sizes facilitate the provision of public goods/common resources. The reason for this is that permitting continuous contributions gives the group a cooperative outcome which can be accomplished by means of symmetric contributions. Likewise, providing public goods/common resources in small groups helps the group focus on symmetric contributions or narrows down the set of both contributors and non-contributors.

We now turn to explore the level of social welfare in each experiment. Bagnoli and McKee (1991) also conducted experiments on voluntary provisions of public goods under a threshold setting, but assumed instead that there was a refund if group contributions fell short of the threshold. They defined social welfare as the sum of all group members' valuations of the public good/common resource plus group endowments minus group contributions. If the public good failed to be provided, then social welfare consisted simply of group endowments since all contributions were returned. Here we follow Bagnoli and McKee's (1991) definition of social welfare, but point out

[10] For groups of five, the successful provision of the public good did not differ from the successful provision of the common resource under both the binary $(F(1, 18) = 2.92,\ p = 0.092)$ and continuous contribution mechanisms $(F(1, 18) = 0.53,\ p = 0.47)$. No framing effect was found for groups of twenty under the binary $(F(1, 18) = 2.61,\ p = 0.111)$ or continuous contribution mechanisms $(F(1, 18) = 1.47,\ p = 0.23)$, either.

Table 5 Welfare Levels per Group (in points)

	Round										
Experiment	1	2	3	4	5	6	7	8	9	10	Total
B-PG-5	870	1,250	1,280	870	1,010	970	1,110	1,290	1,000	730	10,380
B-COM-5	644	1,089	1,078	800	989	811	933	956	811	667	8,778
B-PG-20	1,200	1,333	1,633	1,567	1,533	3,467	1,400	3,267	1,433	1,667	18,500
B-COM-20	1,533	1,467	1,433	1,500	1,200	4,800	4,900	3,233	3,267	1,567	24,900
C-PG-5	408	834	1,119	959	954	975	1,120	1,133	1,269	866	9,637
C-COM-5	701	696	845	1,040	1,047	1,053	893	1,040	1,065	947	9,325
C-PG-20	1,052	1,132	1,150	1,197	3,198	3,087	5,038	3,080	5,070	2,973	26,977
C-COM-20	2,887	2,898	2,912	2,933	891	2,856	4,914	3,013	5,009	3,155	31,468

that because refunds are not allowed in our experiments, social welfare would equal group endowments minus group contributions if the provision were unsuccessful.

Table 5 reports the average welfare levels per group in each experiment. Notice that the maximum welfare level for experiments involving the five-person groups was 1,700 points and that for experiments involving the twenty-person groups was 6,800 points. The maximum average welfare level per subject, which was equal to the maximum group welfare level divided by the group size, was 340 points for both sizes of groups.[11]

The first thing to note is that welfare levels per round were far lower than the maximum welfare level, especially in experiments involving the twenty-person groups, in which welfare levels were often below half of the maximum welfare level.[12] These results sharply contrast with those in Bagnoli and McKee (1991). They found in experiments involving the five-person groups that the maximum welfare level was reached quite successfully within the entire fourteen rounds, and that the maximum welfare level was reached as much as 99% of the time within the last five rounds. In experiments involving the ten-person groups, the maximum welfare level was also reached in

[11] In experiments with binary contributions, the maximum earnings a subject could earn totaled 400 points.

[12] Even when looking at individual groups, welfare levels per round were still often below the maximum welfare level. The data on welfare levels associated with each individual group are available from the author upon request.

Table 6 The ANOVA Results of the Effects of Framing, Group Size, and the Contribution Mechanism on Cooperation, Complete Free-Riding Incentives, the Achievement of Threshold Nash Equilibria, the Provision of Public Goods/Common Resources, and Welfare Levels

Source of Variation (1)	Cooperation (2)	Complete Free-Riding Incentives (3)	Threshold Nash Equilibria (4)	Provision of Public Goods or Common Resources (5)	Social Welfare (6)
Main Effects					
Frame (A)	1.078 (0.3026)	3.425 (0.0683)	0.514 (0.4758)	0.038 (0.8459)	0.118 (0.7323)
Group Size (B)	**20.650 (0.0000)**	**8.609 (0.0045)**	**36.795 (0.0000)**	**32.329 (0.0000)**	**29.483 (0.0000)**
Contribution Mechanism (C)	**38.750 (0.0000)**	**456.358 (0.0000)**	**13.987 (0.0004)**	**4.961 (0.0291)**	2.375 (0.1277)
Interaction Effects					
AB	**35.986 (0.0000)**	**47.468 (0.0000)**	0.018 (0.8926)	**6.922 (0.0104)**	3.967 (0.0502)
AC	0.095 (0.7590)	1.506 (0.2237)	1.056 (0.3077)	0.084 (0.7731)	0.118 (0.7323)
BC	**23.746 (0.0000)**	**26.056 (0.0000)**	**3.984 (0.0497)**	**4.900 (0.0300)**	2.904 (0.0927)
ABC	0.026 (0.8712)	3.642 (0.0603)	2.588 (0.1120)	0.481 (0.4904)	0.571 (0.4524)

The numbers at the top of each entry depict the F statistics, $F(1, 72)$, with the P-values in parentheses. These two numbers are in bold if the effect of the source(s) is significant beyond the $a \leq 0.05$ significance level.

the later rounds. These contrasts confirm Bagnoli and McKee's (1991) conclusion that the provision of refunds in threshold public goods games significantly raised welfare levels.

We shall now look at the effects of framing, group size, and the contribution mechanism on welfare levels. Since group size differs across experiments, we first scale the welfare levels reported in Table 5 by dividing them by the group size in order to obtain the welfare levels for each subject. The ANOVA results in the last column of

Table 6 show that only group size has a significant main effect: the welfare levels per subject were significantly higher in groups of five ($M = 191$ points) than in groups of twenty ($M = 127$ points; $F(1,72) = 29.483,\ p < 0.0001$). Neither framing nor the contribution mechanism had a significant main effect on welfare levels. We also find that the interaction between framing and group size was marginally significant ($F(1,72) = 3.967,\ p = 0.0502$). However, further investigation reveals that no framing effect existed within either the groups of five or the groups of twenty, regardless of the contribution mechanisms.[13] Furthermore, no significant interactions between framing and the contribution mechanism, group size and the contribution mechanism, and framing, group size, and the contribution mechanism were found. We illustrate these findings in Observation 9 as follows:

Observation 9 Welfare levels were significantly higher in groups of five than in groups of twenty. Neither framing nor the contribution mechanism had a significant effect on welfare levels.

Contrasting Observations 8 and 9 shows that even though the continuous contribution mechanism facilitates provision, it has no significant advantages over the binary contribution mechanism in terms of achieving higher welfare levels. The reason for this is that the continuous contribution mechanism induced more over-contributions than did the binary contribution mechanism, and under the no-refund design these over-contributions were simply wasted. By contrast, forming small groups remains an effective approach in both the provision of public goods/common resources and the achievements of social welfare.

5. CONCLUSIONS AND POLICY IMPLICATIONS

In this study, we conducted threshold public goods and common resources experiments to examine the effect of framing, group size, and the contribution mechanism on several issues, including cooperation, the incentive to completely free ride, the attainment of threshold Nash equilibria, the provision of public goods/common resources, and

[13] For groups of five, welfare levels in the public-good frame did not differ significantly from welfare levels in the common-resource frame under both the binary ($F(1,18) = 1.89,\ p = 0.174$) and continuous contribution mechanisms ($F(1,18) = 0.08,\ p = 0.784$). No framing effect was found for groups of twenty under the binary ($F(1,18) = 1.89,\ p = 0.174$) and continuous contribution mechanisms ($F(1,18) = 0.92,\ p = 0.34$), either.

welfare levels. Our experimental evidence shows that group size has a significant main effect in all respects. By contrast, framing has no main effect in any respect, but exhibits an interaction effect with group size in relation to almost all of the issues above. Permitting continuous contributions, on the other hand, has the most salient effect of minimizing the incentives to completely free ride.

Though framing is found to have no main effect, its significant interactions with group sizes indeed provide some evidence in relation to human behavior. Our experimental results show that subjects in the five-person groups were more cooperative in the public-good frame than in the common-resource frame, under both the binary and continuous contribution mechanisms, while the opposite was found to be the case for subjects in the twenty-person groups. This finding suggests that subjects preferred actively giving to passively not-taking when they were in small groups, while in large groups they simply preferred to do the opposite. An analogous result shows that in the five-person groups complete free-riding was higher for the common-resource frame than for the public-good frame, while in the twenty-person groups the outcome was reversed. This result also indicates that subjects in small groups were more aggressive, preferring the active taking-all to the passive giving-nothing, while subjects in large groups preferred the opposite, which was giving nothing. By combining these evidences we see that subjects behaved more aggressively in small groups than in large groups.

The experimental results from this paper have some implications on the provision of public goods and common resources. Recall that threshold Nash equilibria are the only equilibria that satisfy Pareto efficiency. If the policy-makers' objective is to attain Pareto efficiency, then framing the problem of the collective provision of public goods/common resources in a give-some or a take-some context has no effect on achieving this goal. By contrast, providing public goods or common resources in small groups is the most effective way of attaining the Pareto efficient outcome.

Because it is not easy to reach threshold Nash equilibria, policy-makers may alternatively maximize the level of social welfare, and indeed social welfare maximization is often an objective adopted in the public economics literature. Our experimental evidence shows that only group size has a main effect on welfare levels; neither framing nor contribution mechanisms have any effect. Therefore, providing public goods or common resources in small groups is still the most effective way of maximizing social welfare.

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決策架構、群體規模、與捐獻機制在有門檻的公共財與共同資源實驗中對實驗對象合作行為的影響

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摘　要

本文在不同的群體規模與捐獻機制下, 檢驗實驗對象在有門檻的公共財與共同資源賽局中的合作行為。首先, 本文發現決策架構對合作無顯著的主效果, 但和群體規模間的交互效果則是顯著的。具體言之, 在小群體中實驗對象偏好給勝於不拿, 偏好拿取全部勝於完全不給, 但在大群體中實驗對象的偏好則恰好相反。此一發現顯示實驗對象在小群體中的行為較為激進, 但在大群體中則較為被動。其次, 不論是在公共財或共同資源賽局, 實驗結果建議連續捐獻機制可大幅減輕實驗對象完全免費享用的動機。最後, 本文建議在小群體中提供公共財與共同資源是達成柏拉圖效率與極大化社會福利的最有效方法。