DISPOSITION, HISTORY AND CONTRIBUTIONS IN PUBLIC GOODS EXPERIMENTS*

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ABSTRACT

Private incentives to invest in a public good are modeled as self-interested reciprocity where individuals use reputational scoring rules to determine their optimal level of investment. The model predicts that the disposition of any subject to cooperate is revealed by their first period investment in a voluntary contribution experiment, and that grouping cooperative subjects together will improve, and in some circumstances sustain, their private investment in the public good. Actual investment behavior is then studied with laboratory experiments that compare the contributions of subjects randomly reassigned into groups to contributions under a mechanism that sorts subjects into groups based on their individual investment decisions. The sorting mechanism helps to keep subjects with cooperative dispositions together and leads to statistically significant increases, relative to the random matching condition, in cooperators' investments in the public good.

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I. Introduction

Property rights can privatize incentives for the provision of goods that confer public benefits. Unfortunately, it is often unfeasible to implement a property rights system that truly privatizes incentives by making benefits proportional to investments.[1] Nevertheless, there is substantial evidence, including Ronald Coase's (1974) historical research on Great Britain's lighthouse system, that suggests most public goods can be provided privately even without such a system.[2] So how are public goods provided? We provide evidence from public goods experiments, which suggests that grouping those with cooperative dispositions together can lead to sustainable investment in public goods by privately motivated individuals.

Existing experimental evidence on the effects grouping cooperative subjects in public goods games has arisen largely as a by-product of research designed to test theories of altruism and reciprocity (see, e.g., Andreoni (1995) or Croson (1998)). These experiments were motivated, in part, by the well-known results that cooperation in experimental public goods games is much greater than standard economic theories of free-riding predict, and that there is usually decay in cooperation when public goods games are played over multiple rounds (see, e.g., Isaac and Walker (1988)). Andreoni (1995), for example, employed a novel experimental design that took a step towards separating social motives from "confusion" and other sources of high contributions, and concludes that about half of cooperative decay can be attributed to the effects of free-riders. Croson's (1998) results indicate that individual contributions are related to beliefs about and actual group contributions, again providing support for reciprocity theories.[3] We are aware of only one previous paper, Orbell and Dawes (1993), that reports data from experiments that directly examine the effects of separating free-riders from cooperators.[4]

In this paper we experimentally examine the effect that keeping cooperative subjects together has on their public contributions. We use the "Goodwill Accounting" model of self-interested reciprocity, first advanced by McCabe and Smith (1999) and reviewed in the next section, to organize our analysis. One important reason is that the Goodwill Accounting theory provides a simple and testable procedure to classify each subject as either a "free-rider" or a "cooperator." Another reason is that the theory provides testable predictions about the effects of separating the two types based on their respective public contributions.[5] It is worthwhile to point out, however, that the Hypotheses we examine may be consistent with other reciprocity theories. Tests of Goodwill Accounting against various alternatives are left for future research.

The idea behind our experimental design is to compare contributions in a baseline, standard 10-round Voluntary Contribution Mechanism (VCM) experiment, where in each round subjects are randomly arranged into groups of four, to a treatment condition where in each round subjects are sorted, without their knowledge, into groups of four like-contributors. The effect of the treatments, therefore, is to increase the frequency with which cooperators are matched with subjects of similar dispositions, while holding all other aspects of the environment fixed.

We find that both one's disposition to cooperate and one's history of outcomes during the play of the game influence public contributions. In particular, our results suggest that the characteristic decay in public contributions is due primarily to decay in the contributions of cooperators, and that free-riders play an important role in determining the rate of this decay. Specifically, we find that free-riders affect cooperators' contributions because they reduce a group's provision of the public good. This, in turn, reduces cooperators' contributions in subsequent rounds. The magnitude of this effect depends both on the rate at which free-riders and cooperators meet, and on the level of free-riders' contributions. We find two independent effects: First, the more often cooperators interact with free-riders, the faster they lower their contribution. Second, cooperators also decrease their contributions according to how little free-riders contribute. Finally, we find that if cooperators meet free-riders infrequently enough, they sustain their initial public contributions, particularly when the marginal per-capital return (MPCR) to public contributions is not low.

II. Theory and Hypotheses

We make use of the Voluntary Contribution Mechanism (VCM), which is frequently used to examine cooperative behavior (see Davis and Holt (1993) and Ledyard (1995) for reviews). The typical environment includes $i = 1, \ldots, N$ subjects, each with endowment w_i. Subject i contributes g_i to the public good and leaves the remainder in a private account. The total contribution to the public good is summed over all the subjects' contributions; we will denote this aggregate by G. The key to the VCM is that the return on investment in the public account differs from that in the private account. In particular, the return to each person on the total investment in the public account is given by r while, without loss of generality, the return on the private account is set to unity. This means that the payoff function for player i is:

$$\Pi(g_i, g_{-i}) = (w_i - g_i) + rG$$

where g_{-i} represents the vector of contributions of everyone except subject i. As long as $r < 1$ it is easy to see that, given any arrangement of contributions by the other subjects, each player i maximizes her individual payoff by free-riding, that is, by contributing nothing to the public good. At the same time, if $rN > 1$ then it is Pareto optimal for each subject to contribute everything to the public good, and this strategy Pareto dominates free-riding. The parameter "r"

is the marginal per-capital return (MPCR). When designing VCM experiments the MPCR and the number of subjects are usually chosen to exploit the tension between free-riding and Pareto optimality.

Experimental research with the VCM has generated at least three widely replicated results (see Ledyard (1995)). First, cooperation is higher than predicted by standard theories of free-riding, such as the one described above, although there is usually a subset of subjects that contribute very little to the public good. Second, total investment in the public account tends to decay when the VCM is played for several rounds, typically ten, and in the last few rounds contributions are usually much lower than in the first few rounds. Third, contributions to the public good are usually higher when the MPCR is higher.

One theory that is consistent with these results, and which motivates the Hypotheses tested in this paper, is the "Goodwill Accounting" framework by McCabe and Smith (1999).[6] This framework assumes that there are subjective benefits and costs to contributing to the public account, and that a subject's contribution in each round maximizes his expected subjective net benefit. Let the subjective expected cost to subject i in round t of contributing g_{it}, when the MPCR is r, be denoted by $C_i((1-r)g_{it})$, where C_i is assumed to be convex and fixed over rounds. $(1-r)g_{it}$ is the maximum possible pecuniary cost of an increment in g_{it}, holding others' contributions fixed. The subjective expected benefit of contributing is expressed as the product of two terms. The first term is $B_i(g_{it}, r, n)$, where n is the number of subjects in the group. B_i is assumed to be fixed over rounds, concave in g_{it} and increasing in r and n. The subjective expected benefit is assumed to be the product of B_i and a further term that takes account of the subject's beliefs about the characteristics of the people in his group. This second term is $P_i(\alpha_{it})$, where α_{it} is an index that varies over rounds in a way described below, and that is higher when the subject believes the members of his group are more likely to contribute to the public good. [7] The function P_i is assumed to be constant over rounds, non-negative, increasing and bounded. It is important to emphasize that the functions B_i and P_i, are constant over time because they are assumed to reflect individual characteristics and previous experience. B_i and P_i are independent of the specific nature of those with whom an individual interacts. Any effects arising from changes in an individual's beliefs about the willingness of others to contribute to the public good are assumed to be captured by changes in her α. Hence, denoting by w_{it} the period t endowment of subject i, the contribution to the public good in round t solves the following optimization problem.

$$\begin{aligned} Max: \ & P_i(\alpha_{it})\, B_i(g_{it}, r, n) \ - \ C_i([1-r]g_{it}) \\ s.t. \quad & 0 \le g_{it} \le w_{it} \end{aligned}$$

Figure 1 depicts this optimization problem for the special case where $B_i(g_{it}, r, n) = r(n-1)g_{it}$. This payoff arises if subject i expects all members of the group to contribute the amount that she does. Figure 1A shows the effect of varying expected contribution costs with a fixed expected benefit. For instance, a zero contribution boundary solution obtains under the C_i^1 cost function. A full contribution boundary solution results when costs are relatively low, as depicted by cost function C_i^3. Figure 1B shows the effect of varying expected benefits, holding the cost function fixed. Note that contributions are lowest when α_i is lowest. It follows that people free-ride for any of two reasons. First, they may find the subjective cost of contributing too high, which is consistent with the standard maximizing calculus, requiring no expectations about others' behavior. Second, they have a small value for $P_i(\alpha_{it})$. The latter implies that the person expects few contributions to the public good by others.

According to the Goodwill Accounting theory, any changes in an individual's public contributions over time are exclusively caused by changes in α. Such changes are due to modifications in an individual's perceptions about his group. Specifically, since subjects only observe total contributions G_{it}, from which they can infer $G_{-it} = G_{it} - g_{it}$, it is natural to assume that subjects update α so that $\alpha_{i,t+1} < \alpha_{it}$ when the aggregate contribution of other group members, G_{-it} is sufficiently low, and that $\alpha_{i,t+1} > \alpha_{it}$ when the net group contribution is sufficiently high. In particular, suppose that the law of motion for α_{it} is

$$\begin{aligned} &\alpha_{i,t+1} = \alpha_{it} + \lambda_i(G_{-it}) \quad t = 2,...,T \\ &\alpha_{i1} \text{ given} \end{aligned} \tag{1}$$

where $\lambda_i(\cdot)$ is strictly increasing and takes both positive and negative values. The initial value α_{i1} is assumed to depend on a subject's prior beliefs about the likelihood that other subjects will contribute to the public good.

Our Hypotheses are derived from the special case of the Goodwill Accounting model that arises by making the following three assumptions:

A1. Within any MPCR *r*, the endowments w, benefit functions $B^r(\cdot)$ and $P^r(\cdot)$, and cost function $C^r(\cdot)$ are the same for all subjects. However, individuals evaluate payoffs according to their own α_i and one of two updating rules, $\lambda_1{}^r$ *(.)* or $\lambda_2{}^r$ *(.)* where $\lambda_1 r < \lambda_2{}^r$ everywhere along their common domains.

A2. For each MPCR *r* there exists some α^r such that if $\alpha_i < \alpha^r$ then subject i uses updating rule λ_1^r and otherwise they use updating rule λ_2^r.

A3. $B^r(\cdot)$ and $P^r(\cdot)$ are the same for each r while $C^{r_1}(\cdot) < C^{r_2}(\cdot)$ whenever $r_1 > r_2$.

Assumption A1 states that, within any MPCR condition, heterogeneity in contributions is due entirely to heterogeneity in α across subjects. Assumption A2 says that subjects with sufficiently pessimistic prior beliefs will update these beliefs more slowly than those who are sufficiently optimistic. Assumption A3 is that the higher the MPCR, the lower the subjective costs an individual assigns to contributing.

These three assumptions are sufficient to generate several testable implications.

Hypothesis 1: *All else equal and in every round, aggregate contributions to the public account will not decrease when the MPCR is increased.*

Hypothesis 1 follows from the fact that in higher MPCR environments contributions to the public account are less costly.[8]

Hypothesis 2. *Within any MPCR r, subjects who contribute less than an amount $V_r^* \in (0,100)$ in the first round of the experiment will follow a systematically different contribution decision rule than subjects who contribute more than this amount in the first round of the experiment.*

Hypothesis 2 is the foundation of our procedure to classify subjects as either "free-riders" or "cooperators." It follows directly from A2, the assumption that within any given MPCR level, subjects vary only in α_i, and the result that contributions are monotonically increasing in α_i. The important and testable assertion made by this Hypothesis is that individuals can be "typed" based on their initial contribution to the public account (note that the cutoff value V_r^* is not pinned down by the theory; a point we address in section 4). A "free-rider" is someone who contributes a relatively small amount in the first period, and a "cooperator" is someone who contributes a relatively large amount. The nature of the difference that we expect between free-riders' and cooperators' decision rules is clarified by the next Hypothesis.

> **Hypothesis 3.** *Let* $H_{i\tau} \equiv \{G_{-it}\}_{t=1,\tau-1}$ *denote the period* τ *history for subject i (the net group contribution* i *has observed in each period up to period* τ*). If subject "c" is a cooperator and subject "f" is a free-rider, and if* $H_{c\tau} \geq H_{f\tau}$*, then the cooperator will contribute at least as much to the public good in period* τ *as the free-rider will.*

Hypothesis 3 states that if, in every round up to τ, a cooperator observes a net group contribution that is at least as large as the net group contribution a free-rider observes, then the cooperator's contribution to the public good at τ will not be smaller than the free-rider's. This Hypothesis follows from the assumed properties on the α-updating rules $\lambda(\cdot)$.

Hypothesis 4. *An individual's public contribution in period t is weakly increasing in the net contribution of his group in period t-1.*

Hypothesis 4 is obtained by observing that α -updating rules are assumed to be weakly increasing in the net group contribution G_{-it}, and that an individual's public contribution is (weakly) increasing in his α. Note that this Hypothesis does not make any claims about the relationship between a subject's public contributions in adjacent periods. A subject's contribution may rise, fall, or stay the same between adjacent periods and still be consistent with Hypothesis 4. Taken together, Hypotheses 3 and 4 indicate that whether a subject has interacted with cooperators or free-riders in previous rounds should affect her current public contribution decisions. This is made clear by our final Hypothesis.

Hypothesis 5. *Let* $\Gamma_\tau(i,j,k,l)$ *denote a group at round* τ *made up of subjects i, j, k and l. Suppose for some cooperator and free-rider* $H_{c\tau} \geq H_{f\tau}$. *Then*

$[g_{i,\tau+1} \mid \Gamma_\tau(i,j,k,c)] \geq [g_{i,\tau+1} \mid \Gamma_\tau(i,j,k,f)]$, *and similarly for subjects j and k.*

Hypothesis 5 says that a subject who is grouped with a free-rider in round τ will not contribute more to the public good in round $\tau+1$ than he would if that free-rider had been replaced by a cooperator with at least as good a history, while holding the other members of the group fixed.

III. Design

Our experiments were conducted at the Economic Science Laboratory at the University of Arizona. Subjects were undergraduates at the University of Arizona and were recruited from the general student population. A total of 264 subjects, twelve per session, participated. Each subject was seated at a private computer terminal, visually separated from others by blinders, and paid privately at the end of the experiment.

Each of our laboratory sessions included twelve subjects who made decisions into a standard, ten round VCM. Subjects were told that each round their group would consist of four people including themselves. Each subject was given one hundred tokens at the beginning of each round to invest in either a private account which returned one cent per token to that subject alone, or a group account which returned cents at the specified MPCR to everyone in their group including themselves. For example, when the MPCR was 0.5, each token contributed to the public account returned 0.5 cents to each person in the group. After all twelve subjects had made their contribution decisions they were separated into three groups of four. Each subject's earnings were calculated based on the group to which they had been assigned. Finally, subjects were given time to review their results. A new period began when all of the subjects indicated that they were ready.

Table 1 summarizes our experimental design. The design's main feature is the grouping of subjects according to two different rules. The two group assignment rules were crossed with three MPCR levels, r=0.30, r=0.50 and r=0.75. In the baseline conditions subjects were assigned to groups at random. At each round, each subject had an equal chance of being grouped with any three other subjects. In our treatment conditions we used a "sorting" rule. We placed the four highest investors in the public account into a one group, the fifth through the eighth highest investors into another group and the four lowest investors in the public account into a third group.[9] Subjects were given very limited information about the nature of the assignment rule. The exact instructions they received are reported in Appendix A. The only information the instructions contain about the group assignment rule is: *"..., once everyone has submitted his or her investment decision, you will be assigned to a group with four members (including yourself). Your total group investment will then be determined and your experimental earnings calculated."*

The main reason for not telling subjects the assignment rule was the concern that differences in strategic behavior generated by their knowledge of the grouping rule might confound reciprocity effects. For example, a cooperator in the sorted condition who knows the assignment rule and contributes a relatively large amount may be doing so for two reasons. She may contribute because she is not meeting free-riders as frequently as she would in the random condition, or she may simply want to be part of the "top" group. There seems to be no easy way to disentangle these two motives. We chose to circumvent this potential problem by keeping subjects ignorant about the group assignment rule.

Several additional aspects of our design deserve comment. First, note that the "sorted" group assignment rule depends only on the subjects' current contributions. In particular, we do not use any information on whether a subject is a free-rider or cooperator when we form groups. The reason is that the proportion of free-riders and cooperators need not easily accommodate three groups of four individuals. Since our goal was only to reduce the frequency with which free-riders and cooperators meet, our procedure is superior to the alternative of employing a large number of ad-hoc assignment rules to handle various type-contribution combinations.

A second important feature of our design is that, although subjects under different grouping rules do experience different feedback, the VCM's rules, particularly its payoff structure, are identical in all in all experimental sessions. Any learning about its incentives should therefore occur in about the same way in all treatments. It is important to emphasize that there is no reason to suspect that subjects in the sorted treatments knew they were being matched with like-contributors. In principle, of course, a clever subject in the sorted condition could discover something about the grouping rule through systematic experimentation. However, the incentives to experiment are reduced by the fact that all subjects knew that play is limited to ten rounds.

A final point to note about our design is that in the first round subjects in both grouping conditions were in identical situations. Hypothesis 2 states that a subject's initial contribution reveals whether he is a cooperator or a free-rider. Since subjects' situations were identical in the first round, it is reasonable to draw between-condition comparisons in the contributions of subjects of the same type.

The analysis of our experimental data proceeds as follows. We test Hypothesis 1 by comparing aggregate contributions between MPCR conditions. Hypotheses 2 and 3 are tested jointly by first specifying a critical value V_r^* and then comparing the contributions of the resulting free-riders and cooperators within the random condition. We use the random condition because under this condition cooperators and free-riders observe very similar net group contribution histories. Hence, any systematic differences in their contribution behavior in the random condition is evidence of them using different decision rules. We examine whether any systematic differences found are consistent with Hypothesis 3. We test Hypothesis 4 by estimating the importance of previous net group contributions to individuals' decision rules.

Hypothesis 5 is tested by comparing contributions between the random and sorted conditions. The sorted condition effectively replaces some of the free-riders that cooperators encounter in the random condition with other cooperators that have, on average, better contribution histories than the free-riders they replace. Hence, Hypothesis 5 suggests that cooperators' average contributions should not be smaller in the sorted condition than in the random condition. It also implies that cooperator contributions should not decay more rapidly in the sorted than in the random condition.[10]

IV. Results

Figure 2 plots the mean contribution to the public account per period, separately for each cell of our design. The results from the random treatments are consistent with common findings in the public goods literature. In both the 0.75 and 0.50 MPCR conditions, cooperation in the random treatment seems higher than is plausibly consistent with free-rider theories. When the MPCR is 0.3, cooperation in the random treatment decays very quickly. It falls from initial period average contributions of 40 out of 100 to less than ten by period seven, and nearly to zero in the last two rounds. Like Isaac and Walker (1988) and others, we find that when the MPCR is higher both the rate of cooperative decay is slower and, in support of Hypothesis 1, the contributions to the public account are higher.[11] Figure 2 also shows that within each MPCR condition the aggregate contributions in the sorted condition always exceed those in the random condition. Moreover, the decay in contributions is slower in the sorted condition. When the MPCR is 0.3, contributions in the sorted condition begin at about 45 and decay only to 26, but in the two higher MPCR conditions within the sorted treatments there is little evidence of any aggregate decay.

The remainder of our analysis proceeds as follows. First, following Hypothesis 2, we label each subject as either a free-rider or a cooperator based on his first-round contribution to the public account. We then provide statistical evidence that supports this classification procedure. Finally, we analyze the effects that free-riders have on cooperators' public contributions.

IV.A. Classifying Free-Riders and Cooperators

According to Hypothesis 2, a subject's first-round contribution to the public good reveals whether she is a free-rider or a cooperator. In particular, a subject who contributes below a specific cutoff value V_r^*, which may depend on the MPCR, is a free-rider. Anyone whose contribution exceeds V_r^*, is a cooperator. Unfortunately, the particular value of each V_r^* is not pinned down by the theory. Consequently, a certain degree of arbitrariness is unavoidable in our classification procedure. For each MPCR, we chose to classify subjects who contributed 0-30 (out of 100) tokens to the public account in the first round as free-riders and all other subjects as cooperators.[12]

Hypothesis 2 states that free-riders will contribute systematically differently from cooperators. Hypothesis 3 elaborates on Hypothesis 2 by saying that a free-rider will contribute less than a cooperator with the same group contribution history. In the random condition free-rider and cooperator group contribution histories, net of own contribution, should be very similar, whatever the MPCR level. Table 2 shows that this is the case. The table shows mean net group contributions per round for each cell of our design and for both types of subjects.[13] Figure 3, which plots, for each cell, the mean contributions per round of both free-riders and cooperators, shows that in every round and under every MPCR in the random condition cooperators contribute on average more than free-riders do. In the lower MPCR condition (r = 0.3) all of the contributions collapse to zero. This masks any differences in the propensities to contribute, although the hypothesis that the free-rider contribution distribution has a higher median is rejected by Jonckheere (1954) test at standard significance levels in all rounds. On the other hand, when the MPCR is 0.5 the difference in contributions is statistically significant at standard significance levels in all rounds. When the MPCR is 0.75 the difference is significant in all rounds but one.[14]

Table 2 also shows that in the sorted condition cooperator histories are better, on average, than free-rider histories. Hypothesis 3 states that under the sorted condition, free-riders will not contribute more than cooperators. This is supported by the graphs in the right half of Figure 3. We reject at standard significance levels in all rounds and MPCR conditions the hypothesis that the median of the free-rider's contribution distribution exceeds the median of the cooperators' contribution distribution.[15] All of this is evidence in favor of Hypotheses 2 and 3, and therefore supports our classification procedure.

A second way to assess the validity of our classification procedure is to estimate and compare decision rules used by cooperators and free-riders. We investigate whether, as the theory suggests, cooperators within an MPCR but in different treatments (random or sorted) use similar decision rules, whether free-riders within an MPCR but in different treatments use similar decision rules, and whether the cooperator and free-rider decision rules are significantly different.

The arguments to include in the subjects' decision rules are implied by the model of Goodwill Accounting. The same state-variables should enter both the cooperator and free-rider decision rules, and should include the MPCR (from Hypothesis 1), the lagged net group contribution (from Hypothesis 4), and previous individual contributions (since expectations about others' contributions are individual specific and persistent). In addition, it is reasonable to include the round number in order to capture any temporal effects not accounted for by other terms, such as learning about incentives.

We assume that the decision rules can be accurately represented by a model that includes the following regressors: an intercept, a dummy for the 0.5 and 0.75 MPCR conditions, an indicator for the round, the one-period lagged individual contribution and its square, the one-period lagged contribution of the group to which the subject was assigned, (net of the subject's own contribution) and its square, and the interaction of the lagged individual and group contribution. The squared and interaction terms are included to capture nonlinearities in the decision rule. We account for the restriction that contributions must lie between zero and 100, and that there are a substantial number of contributions at both boundaries, by estimating a Tobit specification. That is, we assume that the decision rule that determines the contribution made by subject n at round t depends on their type, denoted by "*a*" and representing either cooperator or free-rider, the vector of state-variables $\mathbf{X}_{nt}$ and an idiosyncratic component ε_{nat} according to

$$c_{nat} = \begin{cases} \mathbf{X}_{nt}^{\prime}\beta_a + \varepsilon_{nat} & \text{if } \mathbf{X}_{nt}^{\prime}\beta_a + \varepsilon_{nat} \in [0,100]. \\ 0 & \text{if } \mathbf{X}_{nt}^{\prime}\beta_a + \varepsilon_{nat} < 0. \\ 100 & \text{if } \mathbf{X}_{nt}^{\prime}\beta_a + \varepsilon_{nat} > 100. \end{cases} \quad (2)$$
$$\varepsilon_{nat} \sim N(0, \sigma_a^2).$$

Here, c_{nat} is the contribution assuming the type is "*a*", β_a is a type-dependent vector of regressor coefficients, and σ_a^2 is the variance of the appropriate idiosyncratic component. Under regularity conditions, the parameter estimates obtained by maximizing the log-likelihood implied by (2) are known to be consistent and asymptotically normally distributed (see, e.g., Amemiya (1985)).[16]

We estimated (2), under the regressor structure described above, separately for cooperators and free-riders and taking the first-round observations as given. There remained 1683 observations on cooperators and 693 for free-riders. There were 197 and 255 "0" contributions for cooperators and free-riders, respectively, while the counts for "100" (full) contributions were 364 and 30, respectively.

Table 3 provides point estimates, in tokens, for the cooperator and free-rider decision rules. The estimates are consistent with the Hypothesis that cooperators and free-riders follow statistically significantly different decision rules.[17] Moreover, cooperators in the random and sorted conditions follow decision rules that are statistically indistinguishable, and similarly for free-riders.[18] These results suggest that, within MPCR conditions, contributions within types differ across treatments (sorting rules) only because the values of the state-variables they use for their decision rules differ across treatments.

As reported in Table 3, the MPCR effect is very small and statistically insignificant for free-riders. For cooperators the effect is larger and significant, and has the expected ordering consistent with Hypothesis 1. The magnitude of the round effect is very small for both free-riders and cooperators. Observe that the estimated decision rules are evidence in favor of Hypothesis 4, in that they are strictly increasing in the lagged, net group contribution for all values of that contribution between zero and 100. This is evidence that both free-riders and cooperators reciprocate previous net group contributions to the public good.

IV.B. Cooperators' Public Contributions

Figure 3 shows free-riders' and cooperators' average public good contributions per cell and per round. In the random condition there is evident decay at each MPCR, although this decay appears to slow as the MPCR increases. In all cells of the random condition, most of the overall decrease in contributions between the first and last rounds is due to decay in cooperator contributions. Within each MPCR, cooperators' contributions in the sorted condition exceed cooperator contributions in the random conditions no later than the fourth round, and continue to do so until round 10. Nonparametric Jonckheere (1954) tests of the significance of the difference between random and sorted conditions show that the distribution of cooperator distributions in the sorted treatments has a significantly higher median within each round, at the 5% significance level, from rounds five through ten when the MPCR is 0.3 and 0.5, and from rounds five through nine when the MPCR is 0.75.[19]

Table 2 also shows average histories for cooperators in each experimental condition. Within each MPCR of the sorted condition cooperators' net group contribution distributions are significantly higher than under the random condition in almost every round.[20] Table 4 provides evidence that the improved histories stem from a reduction in the frequency of encounters with free-riders. The average number of free-riders that each cooperator met per round varied from a high of 1.71 in the random, lowest MPCR condition to a low 0.40 in the highest MPCR, sorted treatment. Hence, the sorted treatment gave cooperators better net group contribution histories by reducing their encounters with free-riders and, in support of Hypotheses 2 and 5, this seems to be the source of their relatively higher public contributions in this treatment.

Given this, Hypothesis 5 suggests that decay in public contributions will be smaller in the sorted conditions. One reasonable measure of contribution decay is the difference between average contributions in the first and last round. By this measure, it is clear from Figure 3 that aggregate decay in the random conditions is due almost entirely to decay in cooperators' contributions and that this decay is very small in the two higher MPCR conditions (0.50 and 0.75) of the sorted treatments.

Figure 4 plots the relationship between the rate of decay in cooperators' contributions and the frequency of their encounters with free-riders. Decay is measured as the difference between initial and final average public contributions. The vertical axis in Figure 4 measures decay, the horizontal axis measures the frequency of encountering a free-rider. The pattern suggests that as the frequency of encounters with free-riders increases, the rate at which cooperators' public contributions decay also tends to increase. This provides support for Hypothesis 5 which states that, all else equal, replacing a group's free-riders with cooperators will lead the group's remaining members to contribute more in subsequent rounds.

Figure 4 shows that when the MPCR is 0.5 and subjects are sorted according to their contributions, decay in cooperators' contributions is smaller than might be expected, given the frequency of encounters between cooperators and free-riders. This is also the only case in which free-rider contributions are significantly higher in the sorted than in the random treatment.[21] The results from this condition can be viewed as further support of Hypothesis 4, which suggests that increasing free-riders' contributions, and therefore improving net group contributions, should lead cooperators to reduce their contributions more slowly.

Although our primary interest is in cooperators' public contributions, it is worthwhile to comment briefly on free-riders' contributions. Within each MPCR free-riders meet each other more frequently in the sorted treatments.[22] Figure 3 shows that this depresses free-rider contributions in the sorted treatments, in relation to the random treatment, within the 0.3 and 0.75 MPCR conditions, although, as noted, this does not occur in the sorted treatment when the MPCR is 0.5.

IV.C. Efficiencies of Payoffs

Our discussion has focused on how separating free-riders from cooperators affects the latter's contribution decisions. It is clear from Figure 3 that sorting in high MPCR environments increased the public contributions of cooperators less than sorting in lower MPCR environments. This does imply that the benefit of sorting, in terms of increased payoffs, is higher within lower MPCR environments. The reason is that when the MPCR is relatively low the efficient payoff, defined as the payoff everyone receives when everybody contributes all of their tokens to the public good, is not very different from the payoff obtained when everybody contributes nothing.

Figure 5 plots average payoffs for free-riders and cooperators in each experimental condition, as a fraction of the efficient payoff. In our experiments cooperators' relative payoff efficiencies increased more when the MPCR was higher, while the efficiencies of free-rider payoffs declined more. The average free-rider payoff in the first round of the random condition when the MPCR is 0.3 is larger than the efficient payoff. The reason is that, for example, if a zero-contributor is matched with three 100-contributers when the MPCR is 0.3 then the zero-contributor receives a payoff of 190.

V. Conclusion

This paper analyzed data from a series of VCM experiments designed to investigate how private contributions to public goods are affected by separating individuals with higher and lower propensities to contribute. Our study was organized by the theory of Goodwill Accounting (McCabe and Smith,1999), a theory of self-interested reciprocity based on reputational scoring.

The theory is consistent with the results of many previous VCM experiments, and several Hypotheses it suggests are supported by the results of this paper.

Our study proceeded by first classifying subjects as either free-riders or cooperators. We then compared contributions across experimental conditions that differed only in the frequency with which free-riders and cooperators interacted. The results of our analysis provide the first direct evidence on the effects of keeping cooperative subjects together in multi-round public goods games.

In the random assignment condition, where cooperators and free-riders interacted frequently, we found characteristic decay in aggregate contributions to the public good. Almost all of this decay can be attributed to decay in cooperators' contributions. In the sorted treatments, where cooperators meet free-riders less often, we found much slower rates of decay. In fact, by sufficiently reducing cooperators' interactions with free-riders we found that, at least when the MPCR is not too low, cooperators' public contributions were sustained.

Our laboratory results lend support and additional explanation for Elinor Ostrom's (1990, 1992) field observations on sustainable commons systems. She derives eight design principles for long-enduring, self-organized commons systems from these observations. One of these is *the Minimal Recognition of Rights to Organize*. This paper's findings are consistent with the view that commons systems are more likely to be enduring if cooperators are given a right to organize into groups of similarly disposed individuals.

Our design and analysis rested on a number of restrictive conditions that future research might relax. One restriction important for our purposes was that subjects were not told about the sorting mechanism. In many actual situations, however, people will know when exclusion restrictions are enforced and this may change their behavior. A second restriction was that the number of subjects in each group was always four, which means that our research has neglected potentially interesting group size effects.

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Appendix A

Exact Transcript of Instructions For MPCR = .5 Experiments

This is an experiment in the economics of group decision-making. You have already earned $5.00 for showing up at the appointed time. If you follow the instructions closely and make decisions carefully, you will make a substantial amount of money in addition to your show-up fee.

There will be 10 decision-making periods. In each period, you are given an endowment of tokens. You need to decide how to divide these tokens between two accounts: a **private** account and a **public** account.

Each token you place in the **private** account generates a cash return to you (and to you alone) of 1 cent.

Tokens that group members invest in the **public** account will be added together to form the group investment. The group investment generates a cash return of 2 cents per token. These earnings are then divided equally between group members. Your group has 4 members (including yourself).

Returns to the group investment are illustrated in the table below. The left column lists various amounts of group investment; the right column contains the corresponding personal earnings for each group member.

Returns from the Group Investment

Total investment by your group	*Return to each group member (From group investment)*
0	**0**
20	**10**
40	**20**
60	**30**

100	**50**
150	**75**
200	**100**
300	**150**
400	**200**

Your records:

Your token endowment for each period, as well as your decisions and earnings, will show on the Record Sheet. Each row on the Record Sheet will represent a single decision period.

Example:

Assume that, in a specific period, your endowment is 100 tokens. Assume further that you decide to contribute 50 tokens to your private account and 50 tokens to the public account. The other group members together contribute an additional 250 tokens to their public accounts. That makes the group investment 300 tokens, which generates 600 cents (300 * 2 = 600). The 600 cents are then split equally among the 4 group members. Therefore, each group members earns 150 cents from the group investment (600/4=150). In addition to earnings from the group account, each member gets 1 cent for every token invested in his/her private account. As you invested 50 tokens in the private account, your total profit in this period is 150 + 50 = 200 cents. Take a look at the Record Sheet. It displays the information for this hypothetical period. During the actual experiment, information will be displayed on the Record Sheet in the same way.

Each period proceeds as follows:

First, decide on the number of tokens to place in the private and in the public account, respectively. Use the mouse to move your cursor to the box labeled "Private Account". To make your private investment, click on the box and enter the number of tokens you wish to allocate to this account. Do likewise for the box labeled "Public Account" Entries in the two boxes must sum to your endowment. To change any of your entries, use the mouse to select what you have previously typed in that box and overwrite. To submit your investment click on the “Submit” button. You will then wait until everyone else has submitted his or her investment decision.

Second, once everyone has submitted his or her investment decision, you will be assigned to a group with 4 members (including yourself). Your total group investment will then be determined and your experimental earnings calculated.

Third, you will receive a message with your experimental earnings for the period. This information will also appear in your Record Sheet.

A new period will begin after everyone has acknowledged his or her earnings message.

After the last period, you will receive a message with your total experimental earnings (sum of earnings in each period).

This is the end of the instructions. If you have finished reading these instructions, push the red bar below.

Appendix B. Contribution Data by Individual

Cooperators in Sorted Condition: MPCR = 0.3

Round	1	2	3	4	5	6	7	8	9	10
1	100	84	75	75	75	75	75	75	75	75
2	100	100	100	100	100	0	0	0	0	0
3	75	100	100	80	85	95	100	75	80	95
4	75	40	60	50	10	10	25	40	0	10
5	100	90	50	0	10	20	30	40	38	40
6	80	60	20	60	80	10	70	30	0	10
Mean	88.3	79.0	67.5	60.8	60.0	35.0	50.0	43.3	32.2	38.3

Cooperators in Random Condition: MPCR = 0.3

Round	1	2	3	4	5	6	7	8	9	10
1	100	100	100	0	0	0	0	20	0	0
2	100	0	0	50	0	0	80	10	0	0
3	75	95	50	25	80	30	25	35	70	0
4	100	0	0	100	0	0	0	0	0	0
5	100	5	95	90	100	0	5	25	3	10
6	100	75	0	20	10	0	0	25	0	2
7	99	50	100	100	0	0	0	0	0	0
Mean	96.3	46.4	49.3	55.0	27.1	4.3	15.7	16.4	10.4	1.7

Cooperators in Sorted Condition: MPCR = 0.5

Round	1	2	3	4	5	6	7	8	9	10
1	100	50	100	100	100	100	100	100	100	100
2	75	65	60	75	50	80	75	50	85	90
3	100	100	100	95	100	100	100	100	100	100
4	100	100	90	80	90	80	70	80	90	80
5	90	90	80	95	100	100	100	90	80	95
6	80	85	80	80	85	75	80	85	90	90
7	80	85	90	95	100	100	85	80	85	80
8	100	90	90	95	95	100	100	100	100	100
9	100	100	100	100	100	100	0	100	100	100
10	99	99	100	100	100	100	100	100	100	100
11	100	100	100	100	100	100	100	100	100	100
12	100	50	50	100	100	100	100	100	100	100
13	100	100	100	100	100	100	100	100	100	100
14	100	100	0	75	100	100	100	100	100	100
15	75	80	85	80	85	80	80	50	80	80
16	75	75	75	100	100	100	100	100	100	90
17	90	50	100	100	100	100	100	100	100	100
18	75	80	60	50	80	60	75	60	75	60
Mean	91.1	83.3	81.1	90.0	93.6	93.1	86.9	88.6	93.6	92.5

Cooperators in Random Condition: MPCR = 0.5

Round	1	2	3	4	5	6	7	8	9	10
1	75	50	15	90	50	25	85	100	0	95
2	75	100	30	25	18	23	25	23	30	25
3	90	100	80	90	80	100	90	50	70	100
4	100	100	100	100	70	70	100	70	70	0
5	100	50	60	100	50	100	80	20	30	50
6	75	80	95	85	50	60	75	60	100	60
7	74	88	89	67	94	47	99	34	45	75
8	100	100	100	60	60	60	100	50	60	60
9	75	80	100	70	20	5	5	5	5	10
10	75	20	95	10	5	70	15	100	35	9
11	80	85	90	99	30	85	90	10	80	100
12	100	100	0	80	100	0	50	0	60	0
13	75	50	25	25	10	40	25	25	15	25
14	100	100	100	100	100	100	100	100	100	100
15	100	75	50	50	25	75	100	0	50	0
16	100	100	100	100	100	75	70	50	15	0
17	100	25	25	25	100	50	25	25	100	25
18	75	25	50	25	50	25	10	90	75	25
19	80	100	90	90	90	50	70	0	0	0
20	75	40	50	25	40	50	30	60	20	40
21	75	75	75	95	0	50	50	0	0	95
22	80	75	100	75	100	80	50	75	70	75
23	100	100	100	0	0	0	0	0	0	0
24	100	100	100	100	100	100	100	100	100	100
Mean	86.6	75.8	71.6	66.1	55.9	55.8	60.2	43.6	47.1	44.5

Cooperators in Sorted Condition: MPCR = 0.75

Round	1	2	3	4	5	6	7	8	9	10
1	100	80	90	100	90	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100
3	85	90	95	95	100	100	100	100	100	100
4	75	90	70	100	100	100	100	100	100	100
5	75	80	90	95	90	96	100	100	100	100
6	75	80	85	90	85	95	95	90	95	85
7	75	90	100	90	100	95	100	100	100	100
8	100	100	100	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100	100	100	90
10	100	100	100	100	100	100	100	100	100	100
11	90	92	100	0	25	1	5	0	0	0
12	80	100	0	0	90	80	100	100	100	100
13	80	80	90	85	86	100	100	100	100	100
14	75	25	75	70	90	99	100	100	100	100
15	75	80	90	85	86	84	85	90	80	0
16	75	100	25	100	100	100	100	100	100	0
Mean	85.0	86.7	81.9	81.9	90.1	90.6	92.8	92.5	92.2	79.7

Cooperators in Random Condition: MPCR = 0.75

Round	1	2	3	4	5	6	7	8	9	10
1	100	100	100	100	100	100	100	100	100	100
2	100	25	50	50	50	0	50	25	0	0
3	100	100	100	100	100	100	100	100	100	100
4	85	90	100	100	80	100	100	50	100	100
5	80	90	90	90	90	90	90	90	100	100
6	75	25	50	65	35	25	20	25	25	50
7	100	100	100	100	100	90	100	100	100	100
8	75	80	80	80	80	80	100	100	100	100
9	100	80	100	100	90	50	60	65	60	100
10	75	75	80	75	50	80	50	75	50	100
11	75	80	75	90	90	100	100	90	90	100
12	90	100	100	0	100	0	0	0	20	0
13	100	100	100	75	100	100	100	50	50	50
14	90	75	100	90	95	95	100	100	90	90
15	80	95	75	85	100	95	90	80	95	70
16	100	100	100	100	100	100	10	0	0	0
17	75	55	60	45	45	45	45	0	0	0
18	75	50	25	50	45	40	30	45	25	45
Mean	87.5	78.9	82.5	77.5	80.6	71.7	69.2	60.8	61.4	66.9

Free-Riders in Sorted Condition: MPCR = 0.3

Round	1	2	3	4	5	6	7	8	9	10
1	30	5	1	0	0	10	0	0	1	0
2	25	30	20	10	25	15	10	10	0	0
3	20	30	50	10	60	10	20	0	1	0
4	0	0	0	0	0	5	10	10	5	0
5	30	0	0	10	10	10	10	10	1	10
6	5	20	1	0	0	2	5	15	10	2
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	30	40	1	1	1	2	1	5	10	0
10	30	0	20	0	1	0	2	2	2	0
11	25	15	30	40	35	35	35	30	30	35
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
Mean	13.9	10.0	8.8	5.1	9.4	6.4	6.6	5.9	4.3	3.4

Free-Riders in Random Condition: MPCR = 0.3

Round	1	2	3	4	5	6	7	8	9	10
1	5	1	5	10	5	1	3	2	1	1
2	0	0	0	0	0	0	0	0	0	0
3	30	25	40	40	10	20	10	10	5	5
4	25	50	75	50	85	50	15	5	1	1
5	5	10	12	20	15	1	10	10	10	5
6	30	0	40	10	0	0	0	40	0	0
7	25	20	20	5	5	4	3	5	10	20
8	0	0	0	0	0	0	0	0	0	3
9	0	0	0	0	0	0	0	0	0	0
10	20	30	30	40	40	30	5	5	0	0
11	20	40	30	50	0	0	0	0	0	0
12	25	25	75	75	15	10	10	10	10	0
13	25	15	0	0	10	0	0	10	0	0
14	30	30	0	20	10	10	0	0	0	0
15	10	20	30	50	30	0	30	0	1	1
16	30	30	50	20	30	70	10	15	30	25
17	10	0	20	50	0	0	0	0	5	0
18	1	1	1	1	1	1	0	0	1	0
19	1	5	10	15	10	1	10	1	1	1
Mean	15.4	15.9	23.1	24.0	14.0	10.4	5.6	5.9	3.9	3.3

Free-Riders in Sorted Condition: MPCR = 0.5

Round	1	2	3	4	5	6	7	8	9	10
1	25	0	0	0	5	0	0	0	0	0
2	25	25	25	50	25	50	75	50	25	25
3	0	20	35	40	50	70	40	45	50	30
4	0	0	0	0	0	0	0	0	0	0
5	25	30	35	50	65	55	50	60	75	35
6	25	50	60	70	75	80	85	90	95	90
7	25	75	90	100	100	100	100	100	100	100
8	0	20	20	30	20	30	0	10	15	15
9	0	0	0	0	0	0	0	0	0	0
10	25	75	90	100	95	65	75	60	65	75
11	25	50	75	100	100	100	100	100	100	100
12	20	20	10	20	25	20	20	30	20	10
13	4	20	88	100	100	100	50	100	100	100
14	0	0	20	30	0	100	100	0	0	10
Mean	14.2	27.5	39.1	49.3	47.1	55.0	49.6	46.1	46.1	42.1

Free-Riders in Random Condition: MPCR = 0.5

Round	1	2	3	4	5	6	7	8	9	10
1	20	30	40	0	10	0	0	10	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	10	0	5	5	0	0	0	0	0
4	0	20	0	25	0	15	0	5	0	25
5	25	15	0	0	10	15	10	15	15	0
6	10	0	30	10	0	0	20	0	0	10
7	20	80	0	0	50	80	0	0	5	1
8	25	50	75	35	0	35	50	35	0	100
9	25	50	40	40	40	40	50	50	40	40
10	20	30	35	10	30	0	25	10	40	10
11	25	70	60	90	60	75	5	70	20	20
12	10	5	1	1	1	5	1	1	1	1
13	25	50	40	40	50	50	50	0	20	25
14	10	0	0	0	0	0	0	0	5	0
15	0	100	100	25	50	75	50	100	0	0
16	30	20	40	50	40	30	0	10	20	10
17	25	75	15	10	12	45	25	65	5	0
18	0	0	0	0	0	0	0	0	0	0
Mean	15.0	33.6	26.4	18.9	19.9	25.8	15.9	20.6	9.5	13.4

Free-Riders in Sorted Condition: MPCR = 0.75

Round	1	2	3	4	5	6	7	8	9	10
1	25	55	80	70	90	100	70	100	75	80
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	25	50	50	55	60	60	50	50	50	0
5	10	8	6	4	1	10	8	10	8	7
6	0	0	0	0	0	0	0	0	0	0
Mean	10.0	18.8	22.7	21.5	25.2	28.3	21.3	26.7	22.2	14.5

Free-Riders in Random Condition: MPCR = 0.75

Round	1	2	3	4	5	6	7	8	9	10
1	0	0	30	50	20	20	0	30	10	0
2	20	50	70	80	80	100	50	65	80	90
3	20	20	20	20	15	15	50	15	75	20
4	20	10	90	50	60	70	40	30	50	0
5	25	20	30	50	70	25	30	25	30	10
6	25	30	25	35	25	30	20	30	40	25
Mean	18.3	21.7	44.2	47.5	45.0	43.3	31.7	32.5	47.5	24.2

NOTES

[1] In the accounting literature, to implement a property rights system requires the ability to make participants accountable for the effect of their actions on a group's outcome (see Dickhaut and McCabe (1997).) Assigning such accountability is often made very difficult by the presence of asymmetric information, the complexity of interactions between individuals and the fact that actions and outcomes measurements are often highly subjective.

[2] Coase reports that lighthouse fees were collected by an agent at port. In our view, the government need not have played much role in enforcing fee collection since the lighthouse's benefits would be clear to its users and any free-riders could be easily discovered and privately punished (see Yamagishi (1985, 1986) for evidence that individuals contribute more readily to the second order public goods problem of providing a functioning system to punish free-riders than to the original public goods problem.)

[3] There is substantial evidence that supports reciprocity in other experimental environments. For instance, Kurzban et. al. (1999) find strong evidence for reciprocity in a real-time public goods game and Berg et. al. (1995) find evidence of reciprocity in an experimental bargaining game.

[4] Orbell and Dawes give subjects the option of not playing a two-person Prisoner's Dilemma game and find that subjects who choose to play the game are more cooperative and thus achieve more efficient outcomes compared to subjects who were forced to play. They argue that subjects who were intending to defect were more likely to choose not to play. We interpret this option as providing a behaviorally induced exclusion device on free-riders.

[5] The Hypotheses we examine may be consistent with other reciprocity theories. Tests of Goodwill Accounting against various alternatives are left for future research.

[6] Alternative theories of reciprocity have been suggested by several others (see, e.g., Sugden (1984), Croson (1998) and Ledyard (1995)).

[7] McCabe and Smith (1999) point out that α_i can often be thought of as a measure of "goodwill" that an individual has towards the group.

[8] More formally, first note that the boundary conditions imply the weak inequality. For interior solutions, first order conditions imply $P_i(\alpha_{it})\ r\ (n-1) = [1-r]C_i'([1-r]g_{it})$. Since C_i is convex, $C_i'$and C_i'' are positive, and C_i' has an inverse, call it D_i, such that D_i' is positive. This allows us to solve for $g_{it}*(r) = Di([P_i(\alpha_{it})\ r\ (n-1)]/[1-r])/[1-r]$. Since $0<r<1$ and D_i' is positive,

$$\frac{d\, g_{it}*(r)}{d\, r} > 0.$$

[9] Ties were broken using randomization. For example, if five subjects in the sorted condition contributed 100, then each of the five unique ways of forming a group of four subjects is equally likely to become the high group.

[10] All of our Hypotheses are tested by examining average play. The reason is that even if the theory is correct and all subjects are classified correctly it is still likely that subjects make decisions with errors. As long as these errors are independent across subjects and rounds it is appropriate to assess the theory by examining means.

[11] All references to Hypotheses refer to those discussed in section II of this paper.

[12] Isaac and Walker (1988) labeled subjects who contributed less than 1/3 of their tokens as "strong free-riders."

[13] Assessing the significance of the difference is cumbersome since the net group contribution series are not independent, and seems unnecessary since the design implies that differences in the series are primarily due to randomness.

[14] We tested the Hypothesis that, within each round, the medians of the free-rider and cooperator contribution distributions are the same against the alternative that the median of the cooperator distributions are higher, using nonparametric Jonckheere (1954) tests. When the MPCR is 0.5 we find in

favor of the alternative at the 1% significance level in all of the rounds. When the MPCR is 0.75 we find in favor of the alternative at the 1% level except in rounds six and nine, and in round nine the difference is significant at the 5% level.

[15] Jonckheere tests of the null Hypothesis that the medians are the same against the alternative that free-riders have a higher median reject the alternative in all cases at the 10% level. Tests against the alternative that the cooperator distribution is higher accept the alternative at the 1% level except in rounds 4 through 10 when the MPCR is 0.5.

[16] Our analysis does not include individual random or fixed effects. The reason is that, as can be immediately seen from the data appendix, many of our free-riders exhibit very little variation in the amount they contribute to the public good. For example, five of 14 free-riders contribute zero every round in the sorted condition when the MPCR is 0.3. Hence, individual effects are either not, or only very weakly, separately identified from the lagged individual contribution effects for many of our subjects.

[17] An F-test of the Hypothesis that the coefficients of the two decision rules are all the same is rejected at the 1% significance level.

[18] To test the similarity of decision rules across the random and sorted treatments we estimated (2) under a regressor structure that interacted a dummy that took the value one in the sorted condition with the round, the lagged individual and group contributions and their square and interaction. Evidence in favor of similar decision rules is found if the coefficients of these six terms are jointly statistically insignificant. For cooperators, the terms are jointly insignificant at the 1% significance level ($F(6,1669)=2.10$). For free-riders, although the six terms are jointly significant at the 1% level ($F(6,679)=4.62$), five of the six terms are jointly insignificant at the 1% significance level ($F(5,679)=2.35$) and the remaining term, the interaction of the sorted condition with lagged individual contributions, is individually insignificant at the 5% level. Hence, in both cases the balance of the

evidence supports the Hypothesis that the decision rules are the same in the random and sorted conditions.

[19] In the first few rounds within each MPCR we cannot reject the Hypothesis that the contribution distributions are the same in both the random and sorted conditions.

[20] Jonckheere tests find that the median of the distribution in the sorted treatments is significantly higher at the 5% level except in round four when the MPCR is 0.3, rounds one and two when the MPCR is 0.5 and rounds one, two, three and ten when the MPCR is 0.75, where we cannot reject the Hypothesis that the medians are the same.

[21] Based on Jonckheere tests, the medians of the free-riders' contribution distributions in the random and sorted condition are indistinguishable in every round when the MPCR is 0.3, but are higher at the 5% significance level in the sorted condition in rounds five, seven, nine and ten when the MPCR is 0.5, and are higher in the random condition at the 5% significance level in rounds three, five, six, nine and ten when the MPCR is 0.75.

[22] The frequencies are, in order of increasing MPCR, 1.2, 0.4 and 0.5 and 1.8, 2.2, and 2.3 in the random and sorted conditions, respectively.

Table 1

Experimental design

Table 1

Experimental Design

Matching Condition	MPCR		
	0.3	**0.5**	**0.75**
Random	3/36/360*	5/60/600	3/36/360
Sorted	3/36/360	5/60/600	3/36/360

***a/b/c where a = number of sessions,**
b = number of subjects, and
c = number of observations.

Table 2

Mean Net Group Contributions by Experiment and Type

	1	2	3	4	5	6	7	8	9	10
	126	93	91	100	39	25	33	17	13	14
	120	84	100	68	62	37	29	29	25	12
	193	180	166	134	147	128	130	133	118	118
	45	37	41	35	46	24	36	23	27	15
	172	189	178	148	133	144	131	113	104	94
	154	148	142	145	110	105	118	91	73	92
	192	194	205	205	213	218	202	203	218	197
	67	96	143	144	156	159	139	154	126	117
MPCR=0.75										
	203	188	212	203	202	187	176	165	168	177
	153	180	222	203	198	201	148	147	142	158
	203	209	205	221	230	236	239	231	224	194
	65	87	91	79	119	103	89	128	76	85

***Average group contributions net of own contributions. "CO" indicates cooperator, and "FR" indicates free-rider.**

Table 3

Estimated Contribution Decision Rules[a]

Coefficient	Cooperators	Free Riders
Constant	**-1.63**	**-12.34**
	(-0.40)	(-3.61)
MPCR=0.5	**10.99**	**2.82**
	(4.74)	(1.51)
MPCR=0.75	**14.26**	**-1.95**
	(5.57)	(-0.60)
Round	**-0.53**	**-0.88**
	(-1.51)	(-2.17)
Lagged Individual Contribution	**0.33**	**1.02**
	(2.90)	(8.35)
Lagged Individual Contribution Squared	**-0.0010**	**-0.0093**
	(-0.90)	(-5.56)
Lagged Group Contribution	**0.16**	**0.18**
	(3.75)	(3.91)
Lagged Group Contribution Squared	**-0.0007**	**-0.0006**
	(-3.98)	(-3.00)
Lagged Individual* Lagged Group Contribution	**0.0032**	**0.0035**
	(6.194)	(5.83)
σ_ε	**33.51**	**23.92**

[a] ***t-statistics in parentheses.***

Table 4

Mean Number of Free-Riders Encountered by Cooperators per Round

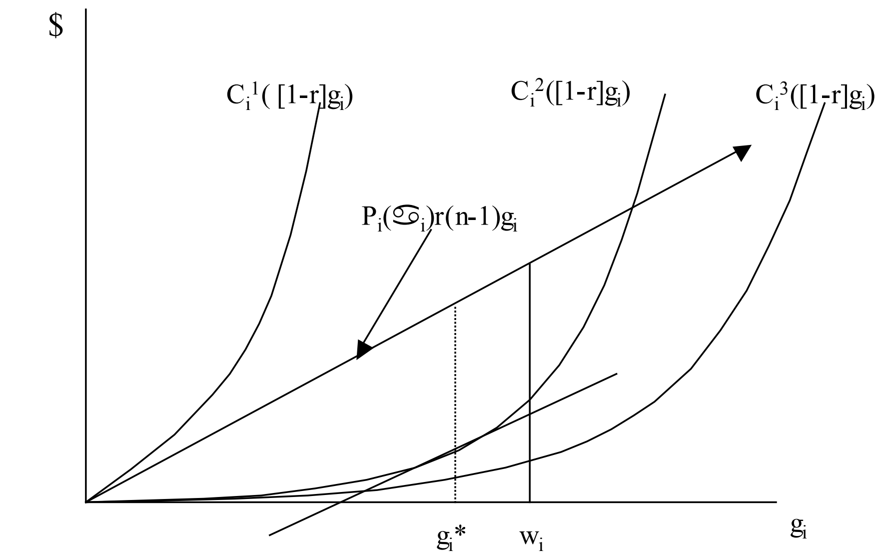
MPCR=0.30	
Sorted	0.70
Random	1.71
MPCR=0.50	
Sorted	0.70
Random	0.82
MPCR=0.75	
Sorted	0.40
Random	0.51

Figure 1

Goodwill Accounting

$$\underset{0 \leq g_i \leq w_i}{\text{MAX}} \quad P_i(\text{♋}_i)r(n-1)g_i - C_i([1-r]g_i)$$

A. Different Cost Functions: C_i^j, $j = 1,2,3$.



B. Different Goodwill Accounts: ♋'< ♋< ♋''

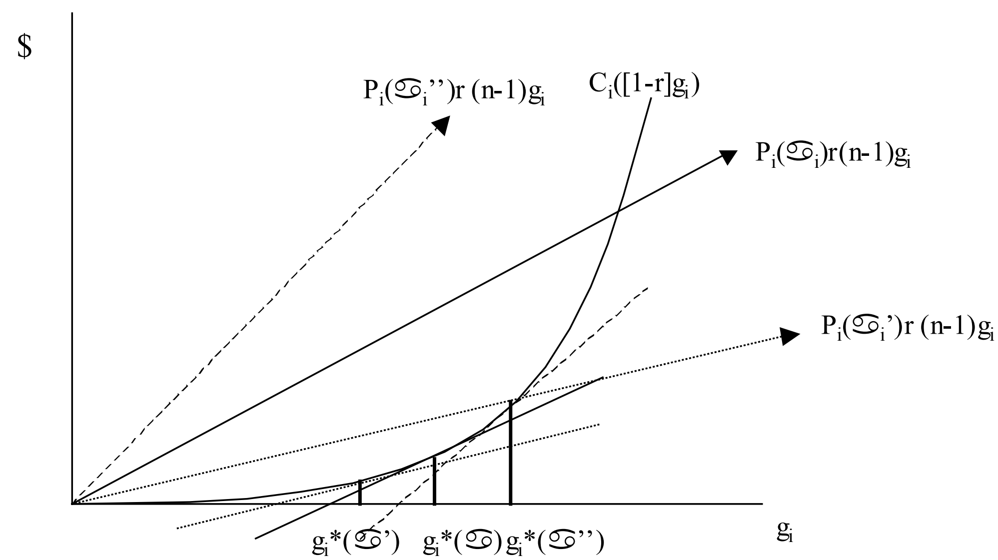


Figure 2

Average Contribution for Each Round by Grouping Mechanism and MPCR

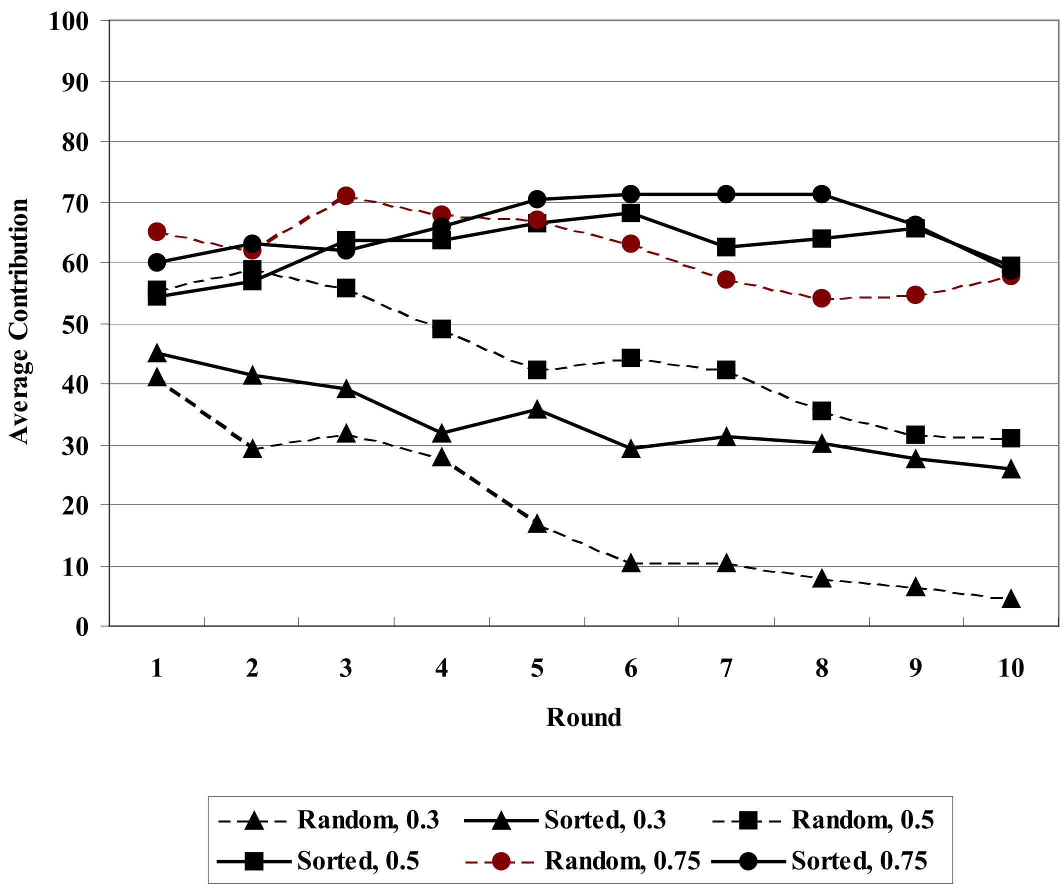
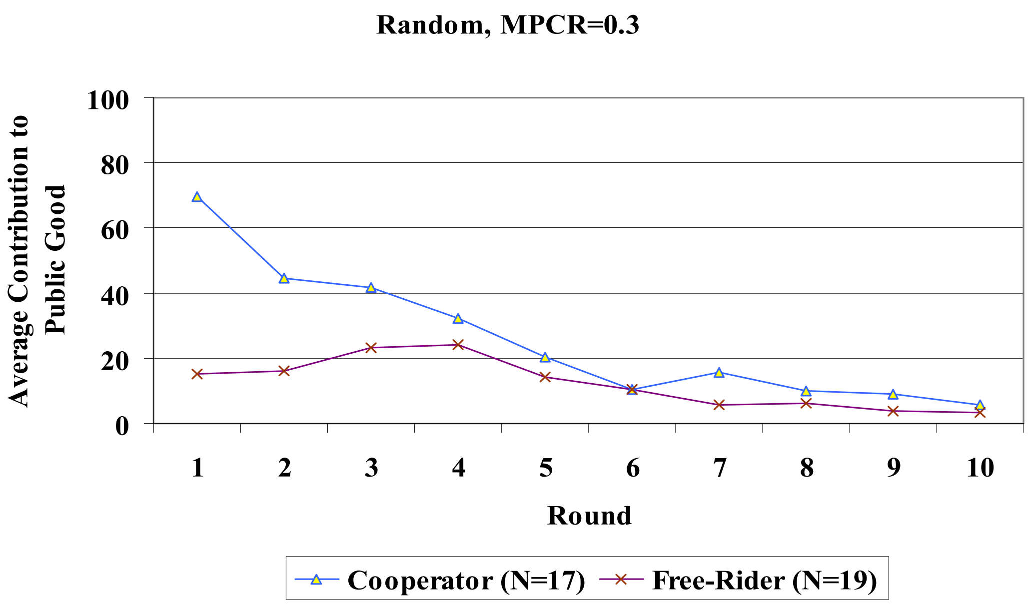


Figure3

<u>Contributions by type</u>



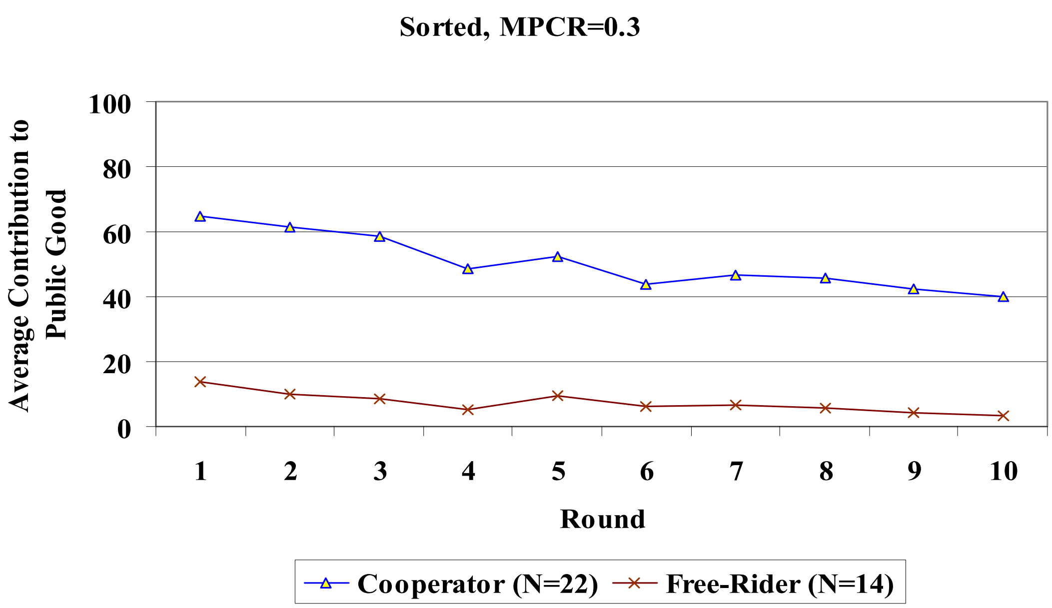
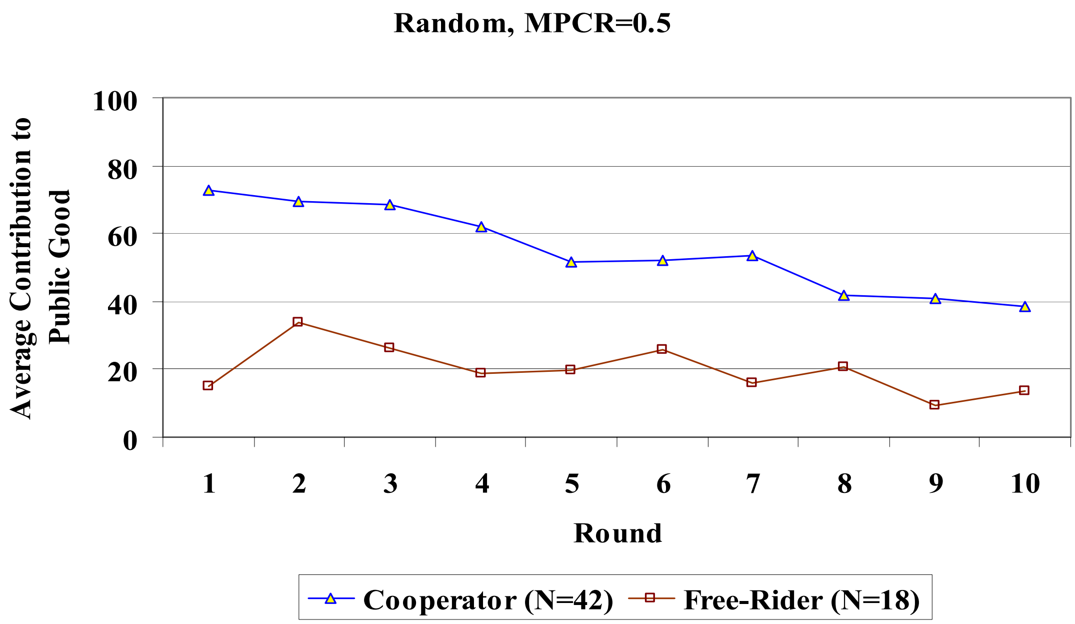
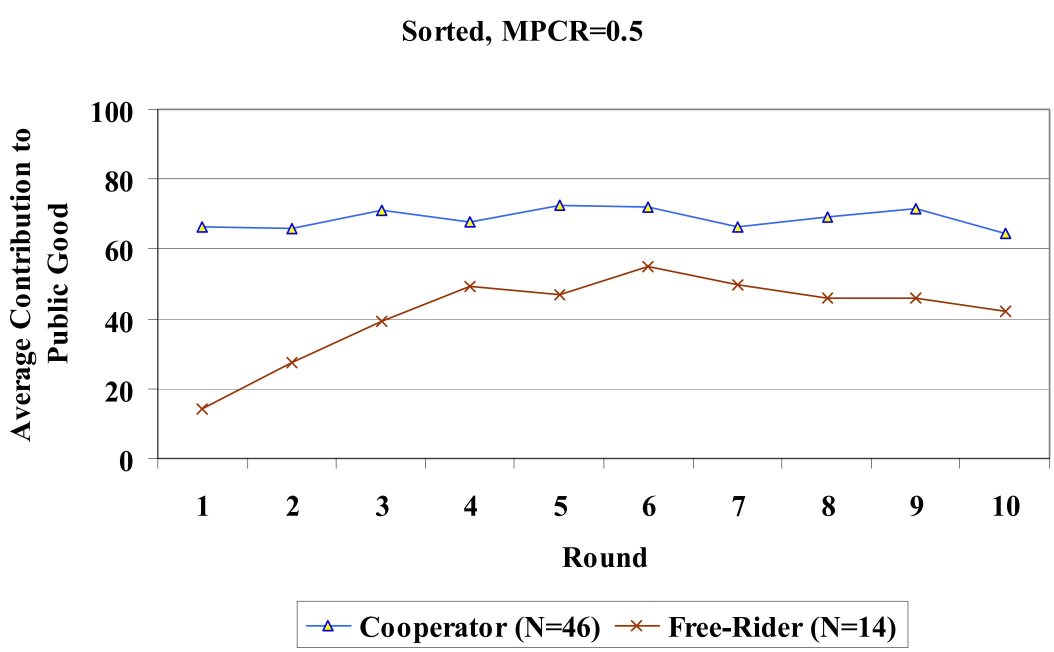


Figure 3 cont.





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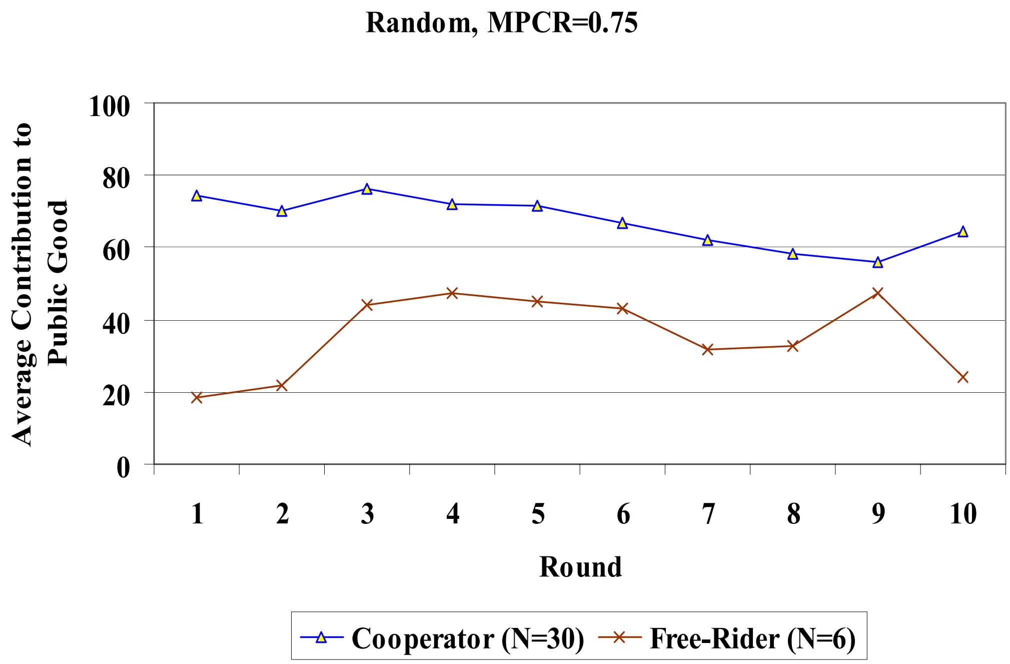


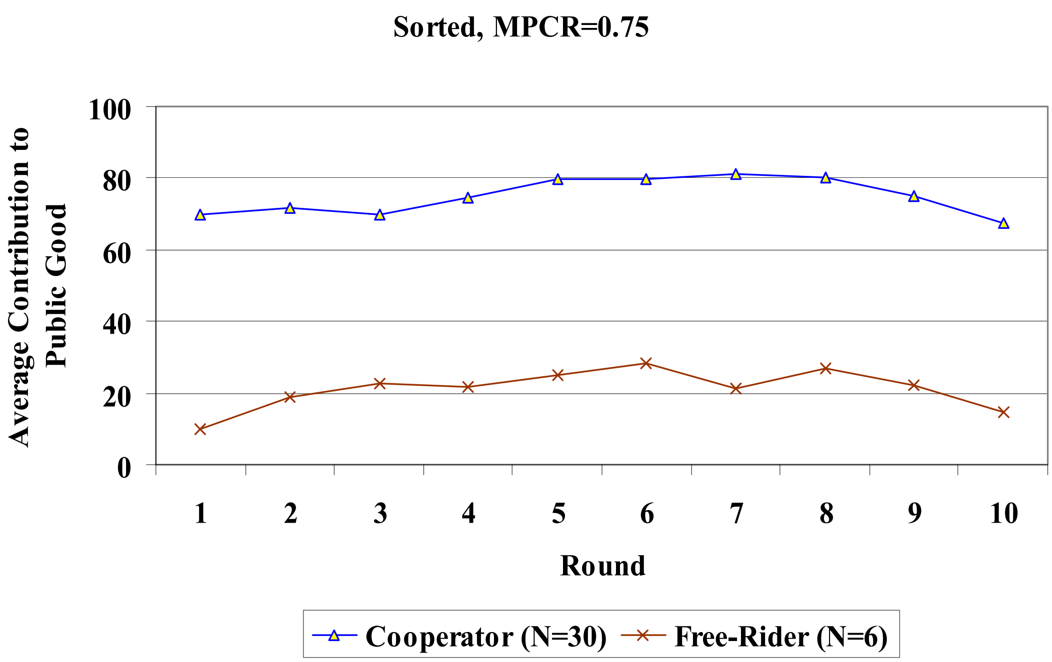


Figure 4

Free-Riding and Cooperative Decay by MPCR and Grouping Condition

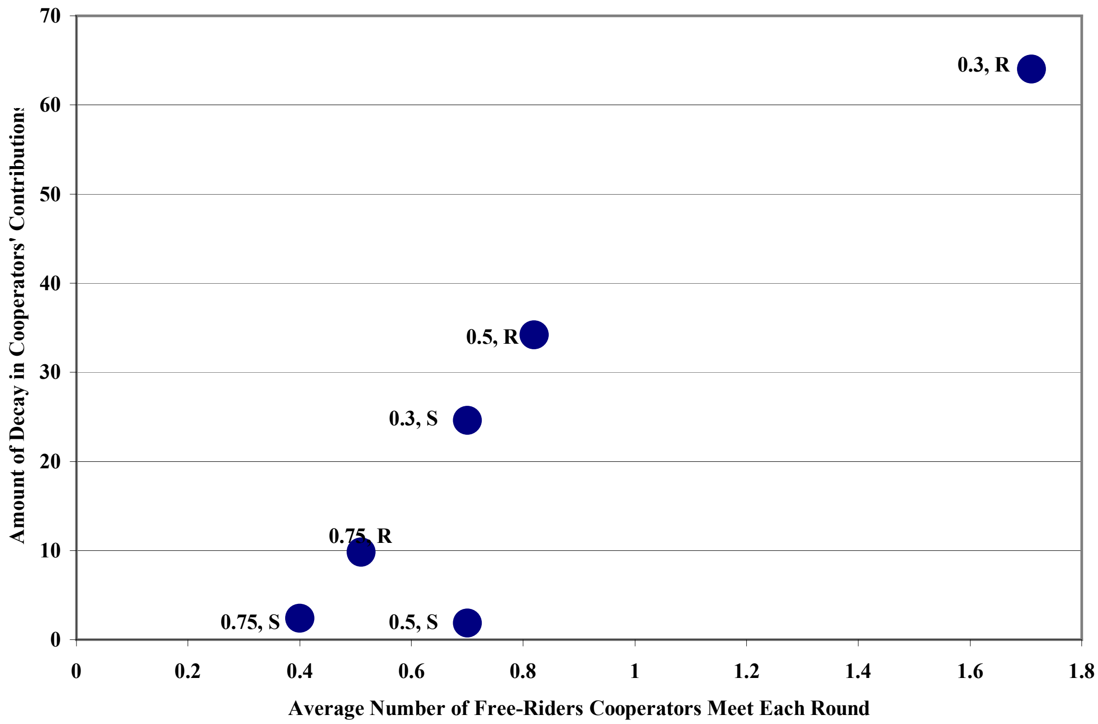
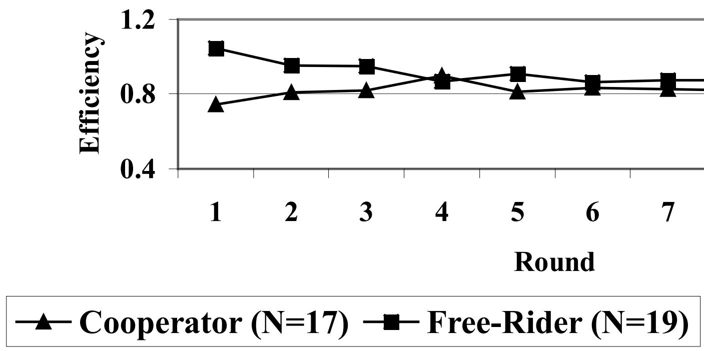


Figure 5

Payoff efficiencies by type

Random, MPCR=0.3



Random, MPCR=0.5

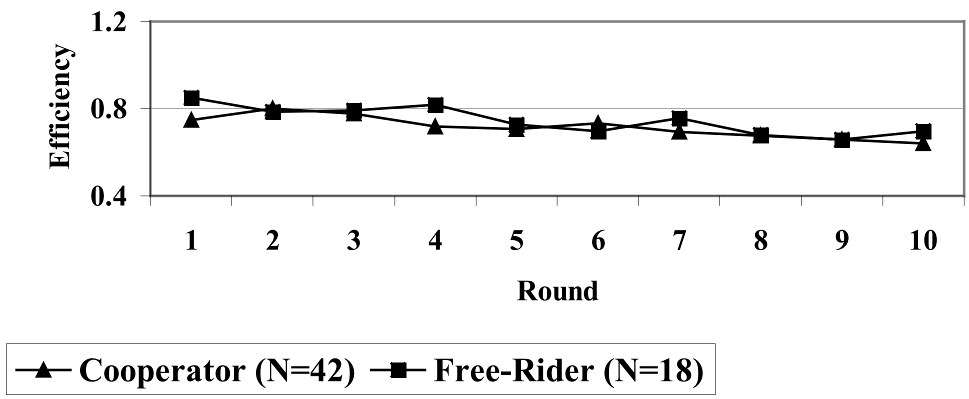
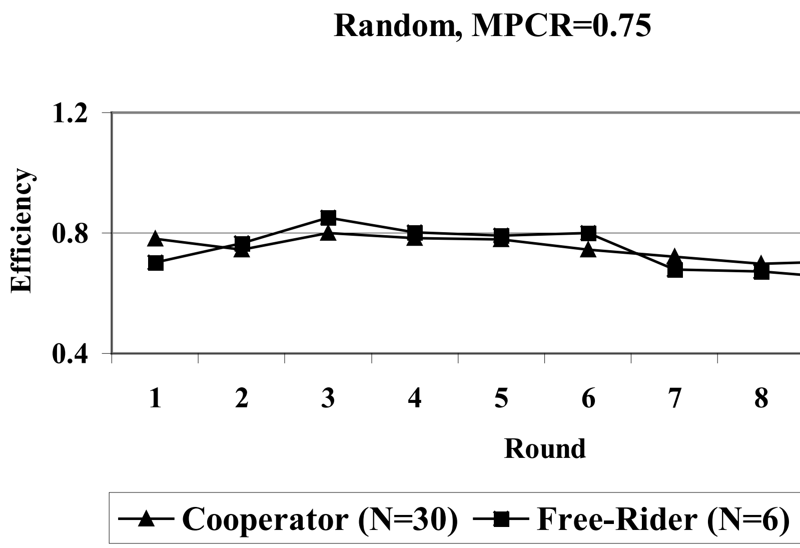


Figure 5 cont.



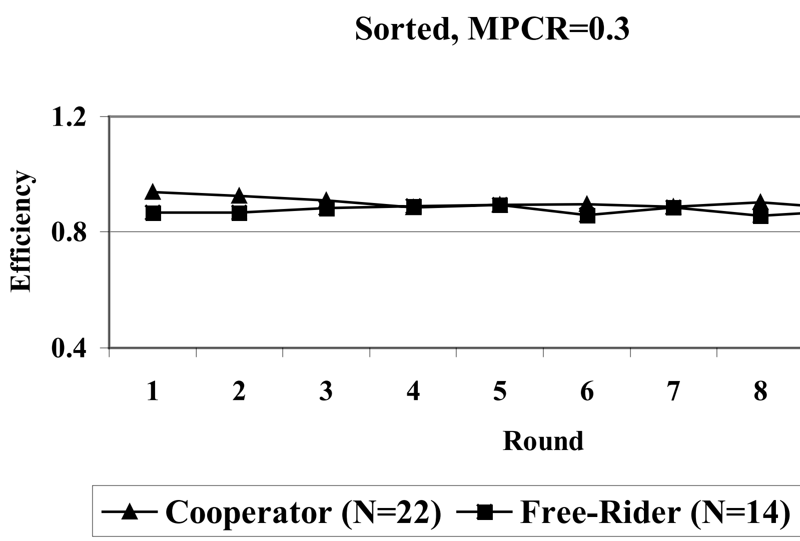


Figure 5 cont.