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Reciprocity, matching and conditional cooperation in two public goods games

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Abstract

Experimental and empirical evidence identifies social preferences and proposes competing models of such preferences. We find that participants match the contributions of others in the voluntary contribution mechanism (VCM). We also examine a game with different equilibria, the weakest link mechanism (WLM). Here, in contrast, participants match the minimum contribution of others.

Keywords: Experimental economics; Public goods; Voluntary contribution mechanism; Weakest link mechanism

JEL classification: C72; C92; D44; H41

1. Introduction

A recent spate of theories has emerged to explain prosocial preferences as observed in experiments and in real life (see Sobel, 2001 for an outstanding review). This paper focuses on one category of these preferences—reciprocal or matching preferences. We present experimental results testing the existence

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and forms of these preferences from two public goods environments, the well-known linear public goods game [voluntary contribution mechanism (VCM)] and the relatively understudied weakest link mechanism (WLM).

In the VCM, the amount of public good produced depends on the total of individual contributions. Both theoretically and experimentally, this mechanism generates relatively low efficiency. In the WLM, the amount of public good produced depends on the minimum of all contributions.[1] It gives rise to multiple equilibria, one of which is perfectly efficient. Experimentally, the WLM promotes efficiency in sequential environments (as in Weber et al., 2003), but the results are far less solid in simultaneous settings (Van Huyck et al., 1991).

Note that, whereas the VCM has a unique dominant strategy equilibrium, WLM has a continuum of pure strategy Pareto-ranked Nash equilibria (when the action space is continuous and has a multiplicity of equilibria when it is discrete). In this paper, we examine the decision-making processes in the two institutions. First, we find deviations from equilibrium predictions in both institutions. Second, we find evidence for reciprocity (or matching) as an explanation for that deviation in both institutions.

The rest of the paper is organized as follows: Section 2 discusses the two games and their experimental implementation. Section 3 reports the experimental results, and Section 4 concludes.

2. The experimental environment

2.1. The voluntary contribution mechanism (VCM)

In economic experiments, the most common public goods institution is the VCM (see Ledyard, 1995 or Keser, 2002 for a review). In our experiment, four subjects are endowed with e_i=50 cents and are asked to simultaneously and privately allocate this endowment between a public and a private account. The payoff of each individual i is determined by the sum of his or her allocation to the private account and half of the group's total allocation to the public account. In the stage game, player i has a dominant strategy to free ride for any given allocation of his or her three partners. This game is typically repeated finitely many times, leading to a Nash equilibrium outcome of full free riding. Yet, this outcome is socially inefficient.

2.2. The weakest link mechanism (WLM)

The setting in the WLM is the same; groups of size four, and each individual has 50 cents to allocate between the two accounts. However, in the WLM, participants earn the sum of their allocations to the private account and twice the group's minimum allocation to the public account. In the stage game, there are multiple Nash equilibria which coincide with the set of all symmetric strategy profiles. Since participants are limited to allocate in whole pennies and each has 50 cents to allocate, there are 51 symmetric Pareto-ranked equilibria. Complete allocation of all endowments to the public account is the

[1] The WLM was introduced by Hirshleifer (1983). Harrison and Hirshleifer (1989) conceptualize the WLM as a kind of veto power over the extent of collective achievement, and it has been proposed as a useful approach to real life coordination problems, from disasters (like floods) to assembly lines.

Pareto-efficient equilibrium. Any unit allocated to the public account in excess of the minimum is socially inefficient.

2.3. The experimental procedure

In this paper, we report the results of computerized experiments, which replicate closely the environment, particularly the information and payoff structure, of Croson's (2000) VCM with individual information.[2] The experiments involved 24 economics undergraduates in each treatment, organized into groups of four from a room of 12. None of the participants had previously participated in a public goods experiment.

The experiments entailed 10 periods of the VCM (or the WLM), with another 10-period surprise restart game.[3] Participants were randomly chosen to form groups of four in the first period and remained together throughout both the original and the restart game. Instructions were written in neutral language, referring to allocations of tokens rather than contributions. Before the experiment, participants completed a quiz to ensure that they understood the payoffs involved in the experiment, and there was a postexperimental survey to elicit participants' thoughts about the experience. Instructions, quiz and surveys are available from the authors.

After each round, participants were told the individual contributions of the other three members of their group in increasing order of contribution; individual contributions were not identified with their contributor such that it was impossible to trace individual contributions (as in Croson, 2000). Additionally, subjects were informed about their own earnings both in total and subdivided by private and public accounts. Average earnings of a subject were 10.43 in the WLM experiments and 13.06 in the VCM. Experiments took less than 1 h to run.

3. Experimental results

3.1. Average contributions

Fig. 1 shows the average contributions to the public good in each of the two environments over the 20 rounds.

Replicating previous studies, we find behavior that is significantly different than that predicted by equilibrium analysis. Allocations to the public good in the VCM are significantly different than zero, starting at around 40% of endowment and then declining over the length of the game. Allocations in the WLM are also not at equilibrium; in 118 out of the 120 periods (20 periods for each group times six groups), the individuals in the groups allocated different amounts to the public good.

We also observe contributions decreasing over the 10 periods in the game, consistent with previous experiments. A regression of group contributions on period number and including an indicator variable for each group and for the restart game produces a significantly negative coefficient for both the VCM (β=−6.381, p=0.0000) and the WLM (β=−3.594, p=0.0000).

[2] Urs Fischbacher's z-tree was used for the computer programme.

[3] The restart technique has been investigated in repeated public goods experiments (see, e.g., Andreoni (1988), Croson (1996, 2000), Andreoni et al. (forthcoming) provide a review).

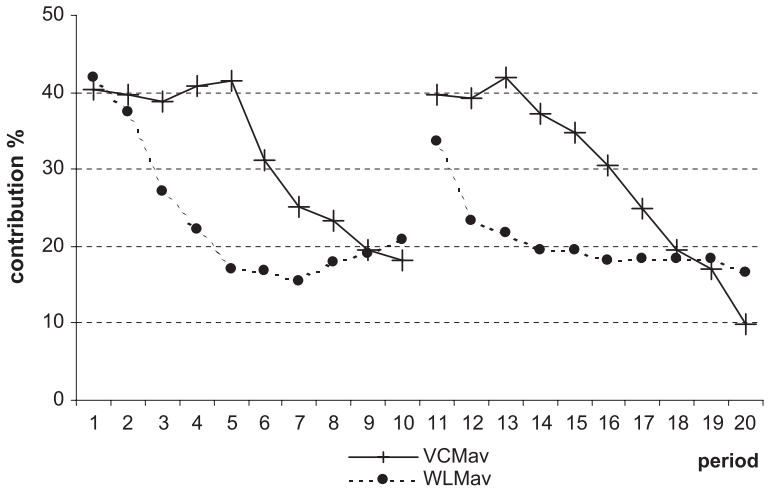

Fig. 1. Average allocations to the public good.

Finally, these data replicate the restart effect, observed by Andreoni (1988) and Croson (1996) in VCM experiments. We observe a restart effect in both environments. If we treat each group of four as an independent observation, a Wilcoxon test compares contributions in round 10 (the last round of the original game) and round 11 (the first round of the restart game). These differences are significant for the VCM, p=0.028 and for the WLM, p=0.046. Thus, we conclude that participants significantly increase their contributions when the game restarts.

3.2. Conditional cooperation

The focus of our paper is on identifying the decision rules in these environments. A number of competing models have been proposed to explain results, like those found above. One set of those models involves reciprocity (also called matching, also called conditional cooperation).[4] In these models, participants try to match the allocations of their counterparts. Thus, if others contribute to the public good, you want to contribute, while, if others free ride, you want to keep your endowment for your private consumption.

We follow Croson (1998) in analyzing the allocations to test this explanation. The regressions are run separately for the original game and the restart game. The dependent measure is individual i's contribution to the public good in period t. Independent variables include the period t, indicator variables for each individual and, of most interest, a measure of what an individual's counterparts did last period.

For the VCM, we use the average allocation to the public good of the other three members of your group in the previous period as this measure. Croson (1998) showed that this average is salient to the participants and related to their own allocations. For the WLM, we use the minimum allocation to the public good of the other three members in your group in the previous period as this measure. Note that this is not necessarily the amount of the public good that is provided (the participant's own allocation

[4] See, e.g., Sugden (1984), Andreoni (1995), Palfrey and Prisbey (1997), Croson (1998), Sonnemans et al. (1999), Fischbacher et al. (2001), Keser and van Winden (2000), and Brandts and Schram (2001).

Table 1
Random effects regression results (S.E.)

Voluntary contribution mechanism			Weakest link mechanism		
	Original	Restart		Original	Restart
Constant	15.113** (3.330)	15.508** (4.084)	Constant	9.873** (1.737)	10.665** (0.758)
AverCont_{t-1}	0.402** (0.118)	0.415** (0.150)	MinCont_{t-1}	0.478** (0.102)	0.225** (0.070)
Period	−1.062** (0.283)	−1.319** (0.331)	Period	−0.350*** (0.209)	−0.303** (0.074)
Individual dummies	Yes	Yes		Yes	Yes
R^2	0.6339	0.5299	R^2	0.4496	0.8667

*$p<0.05$.
** $p<0.01$.
*** $p<0.10$.

may have been less than those of his three counterparts). However, we believe that this measure is salient to the participants in the WLM.[5] The regressions are run using random-effects regression.[6] Thus, the equations are

$$\text{Model VCM: } \text{cont}_{it} = \beta_0 + \beta_1 \text{AverCont}_{-it-1} + \beta_2 t + \alpha_i + \varepsilon_{it}$$
$$\text{Model WL: } \text{cont}_{it} = \beta_0 + \beta_1 \text{MinCont}_{-it-1} + \beta_2 t + \alpha_i + \varepsilon_{it}$$
$$\forall i = 1,2,\ldots,24 \text{ and } \forall t = \{2,3,\ldots,10\},$$

where cont_{it-1} is i's lagged contribution, AverCont_{-it-1} denotes the lagged average contributions of i's partners in the previous period, and MinCont_{-it-1} denotes the lagged minimum contribution of i's partners, t is the period number, and α_i are the individual indicator variables. The results are presented in Table 1.

As can be seen in Table 1, the coefficients on the measure of others' allocations are positive and significant in both environments and for both the original and the restart games. This lends support to the reciprocity or matching explanations suggested to explain our results.

We can also do this analysis at the individual level. For each individual, we calculate the correlation between their allocations to the public good and their counterparts' lagged measure (average or minimum) over the 20 periods. Of the 48 individuals in our experiment, 45 of them have positive correlations between their own allocations to the public good and the appropriate measure of their counterparts' allocations. This is significantly different than what would have occurred by chance; a binomial test of the null hypotheses that half these correlations are positive and half are negative is soundly rejected ($p<0.0001$).

[5] We have also run a number of additional specifications, including using the middle of the other three contributions instead of the average, including the minimum and the maximum in the VCM regression, and the average, the middle and the maximum in the WLM regressions. All have similar results as those described here: individuals' contributions are positively related to the previous contributions of others and support our contention that, in the VCM, participants focus on the average contributions, and, in the WLM, participants focus on the minimum contribution.

[6] This approach has been used, for instance, in Croson (1998). The random variables α_{ki} of the model account for idiosyncratic behavior and are uncorrelated to the white noise error terms ε_{kit} for each subject i and in period t. For further reading, see Greene (2000).

4. Conclusions

Our data replicate previous results from the voluntary contribution mechanism and point out similarities between the patterns of allocations to the public good there and in the weakest link mechanism. In both games, initial allocations average around 40%, decline over the length of the game and restart significantly when the game is restarted. Equilibrium play is hardly ever observed.

We provide evidence for one model behavior in these games, reciprocity (or matching or conditional cooperation). Consistent with Croson (1998), we find that participants in the VCM attempt to match the contributions of others in their group. Subjects in the WLM, in contrast, attempt to match the minimum contribution of others in their group.

This evidence suggests some directions that theories developing to explain cooperative behavior, like that observed here, might take. Focusing on the impact of social comparisons, the other players' actions and individuals' desires to conform to them are likely to be useful paths to follow.

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References

Andreoni, J., 1988. Why free ride? Journal of Public Economics 37, 291–304.

Andreoni, J., 1995. Cooperation in public goods experiments: kindness or confusion? American Economic Review 85 (4), 891–904.

Andreoni, J., Croson, R., forthcoming. Partners versus strangers: random rematching in public goods experiments. In: Plott, Smith (Eds.), Handbook of Experimental Economics Results.

Brandts, J., Schram, A., 2001. Cooperation or noise in public goods experiments: applying the contribution function approach. Journal of Public Economics 79 (2), 399–427.

Croson, R.T.A., 1996. Partners and strangers revisited. Economics Letters 537, 25–32.

Croson, R.T.A., 1998. Theories of altruism and reciprocity: evidence from linear public goods games. Working Paper, The Wharton School.

Croson, R.T.A., 2000. Feedback in voluntary contribution mechanisms: an experiment in team production. Research in Experimental Economics 8, 85–97.

Fischbacher, U., Gächter, S., Fehr, E., 2001. Are people conditionally cooperative? Evidence from a public goods experiment. Economics Letters 71, 397–404.

Greene, W., 2000. Econometric Analysis. Prentice Hall, New York.

Harrison, G., Hirshleifer, J., 1989. An experimental evaluation of the weakest link, best shot models of public goods. Journal of Political Economy 97, 201–225.

Hirshleifer, J., 1983. From weakest-link to best-shot: the voluntary provision of public goods. Public Choice 41 (3), 371–386.

Keser, C., 2002. Cooperation in public goods experiments, mimeo. Cirano.

Keser, C., van Winden, F., 2000. Conditional cooperation and voluntary contributions to public goods. Scandinavian Journal of Economics 102 (1), 23–29.

Ledyard, J., 1995. Public goods: a survey of experimental research. In: Kagel, J., Roth, A. (Eds.), Handbook of Experimental Economics. Princeton University Press, Princeton.

Palfrey, T.R., Prisbey, J.E., 1997. Anomalous behavior in public goods experiments: how much and why. American Economic Review 87 (5), 829–846.
Sobel, J., 2001. Social preferences and reciprocity, mimeo. UC at San Diego.
Sonnemans, J., Schram, A., Offerman, T., 1999. Strategic behavior in public goods games: when partners drift apart. Economics Letters 62, 35–41.
Sugden, R., 1984. Reciprocity: the supply of public goods through voluntary contributions. Economic Journal 94, 772–787.
Van Huyck, J., Battalio, R., Beil, R., 1991. Strategic uncertainty, equilibrium selection principles, and coordination failure in average opinion games. Quarterly Journal of Economics 106, 885–911.
Weber, R.A., Camerer, C., Knez, M., 2003. Timing and virtual observability in ultimatum bargaining and 'weak link' coordination games, mimeo. Carnegie Mellon University.