“Contribution to Public Goods: Altruism or Reciprocity?”

96-08-01

Rachel Croson
CONTRIBUTIONS TO PUBLIC GOODS:
ALTRUISM OR RECIPROCITY?

Rachel T. A. Croson

96-08-01

Department of Operations and Information Management
The Wharton School
University of Pennsylvania
Philadelphia, PA 19104-6366

Also available as a working paper of the Risk Management and Decision Processes Center
Contributions to Public Goods: Altruism or Reciprocity?*

Rachel T.A. Croson
CrosonR@opim.wharton.upenn.edu
July, 1996

Abstract

This study examines factors which motivate individuals to make contributions to public goods. Traditional economic theories of altruism imply a negative correlation between an individual's contribution and the contributions of others (Becker, 1974; Andreoni, 1989, 1990). In contrast, theories of reciprocity (Sugden, 1984) are consistent with a positive correlation. The experiment described in this study compares an individual's contribution to a public good with the contributions of others in his group, as well as with his belief about their contributions. Individual contributions are significantly positively related both to the contributions of others and to beliefs about those contributions, providing support for reciprocity theories over theories of altruism.

Keywords: Public Goods, Charitable, Contribution, Experiment

JEL Classification Code: C9, D64, H41, C72

*The author thanks Jon Baron, Robyn Dawes, Jerry Green, Mark Isaac, Eric Maskin and George Wu for helpful comments. All omissions or mistakes are the responsibility of the author. Funding of experiments from the Economic Science Lab at the University of Arizona is gratefully acknowledged.
1. Introduction

US individuals made over 100 billion dollars of philanthropic contributions in 1995 (Giving USA, 1996).\(^1\) This behavior is inconsistent with traditional utility theory in which individuals care only for their own consumption. Under those assumptions optimal contributing behavior toward public goods involves free, cheap or easy riding on others' contributions. Much research in economics has focused on developing incentive-compatible mechanisms designed to overcome this free-riding problem.\(^2\)

Another stream of research has involved modeling either the act or consequences of charitable giving to public goods as a good in its own right. Becker (1974), Sugden (1984) and Andreoni (1989, 1990) present varying models of voluntary charitable giving.

In Becker's model of (pure) altruism the welfare level of others appears positively as an argument in an individual's utility function. In Andreoni's model of impure altruism the utility function of individuals includes positively both the welfare level of others and the amount the individual has contributed to that welfare. These models of altruism both imply a negative correlation between an individual's contributions and the contributions of others (or beliefs of the contributions of others). Since the welfare of others is a normal good, as it improves the individual spends less on it and more on private consumption.

In contrast, Sugden proposes a theory in which the principle of reciprocity acts as a constraint on traditional individual utility maximization. The principle says roughly that an individual may not free, cheap or easy ride when others are contributing. Behavior which emerges from this model is consistent with a positive correlation between an individual's contributions and the contributions of others (or beliefs of the contributions of others). If others contribute more and the principle of reciprocity binds then the individual contributes more as well.

This study provides an experimental test of the implications of these theories. The experiment involves a finitely repeated public goods game. Subjects estimate how
much others in their group will contribute in the upcoming round before contributing themselves. Subjects are paid for accurate estimates and receive earnings from the public and private goods. The results of this experiment suggest a significant and positive relationship between both an individual’s own contribution and the contributions of the others in his group and his individual’s belief of the contributions of others in his group and his own contributions.

This paper is organized as follows. Section 2 describes the public goods production function and the voluntary contribution mechanism used in this experiment. Section 3 outlines three classes of theories and their implications and section 4 reviews relevant literature. Section 5 describes experimental methods and procedures while section 6 presents the results of the experiment. Section 7 discusses the results and concludes.

2. Pure Public Goods and the Voluntary Contribution Mechanism

Pure public goods are goods that are both nonrival and nonexcludable. The experiment described in this paper uses a linear and pure public good. The mechanism used to fund the public good is the voluntary contribution mechanism which most closely parallels philanthropic giving or contributing behavior.

Assume each player $i$ in a group of $N$ identical players has some endowment $E_i$ which can either be contributed to a group account and used to produce units of a public good or can be privately consumed. Call the amount contributed to the group account by $i, x_i$. The individual’s earnings from private consumption is simply the amount consumed ($E_i - x_i$). The individual’s earnings from contributions to the group account is a multiple of the sum of contributions by all participants $P(\Sigma x_i)$. There is a pure public goods problem whenever $\frac{1}{N} < P < 1$. When $P < 1$, contributing to the public good is never optimal for the self-interested individual. Contributing one unit to the public good earns him only $P$, and costs him 1. When $\frac{1}{N} < P$, contributing to
the public good is always optimal for the group as a whole. Contributing one unit to the public good costs an individual 1, but earns NP for the group.

This mechanism of contributions to the public good in this game is purely voluntary, similar to the institution of charitable contributions.

3. Three Theories and Hypotheses

In traditional utility theory individuals care only about their own payoffs. Under these assumptions when a pure public goods problem is faced there is a unique dominant strategy equilibrium in which all players fully free ride (contribute zero). In this free riding equilibrium, an individual's contribution is independent of what others in the group contribute. Thus our first free riding hypothesis is that there will be no correlation between what an individual contributes and what others in the group contribute. This hypothesis is perhaps badly named, as its prediction of zero correlation is consistent with other theories of charitable giving. For example, Laffont (1975), Collard (1978, 1983) and Harsanyi (1980) analyze commitment rules in which an individual contributes the amount that he would most prefer every member of the group would contribute, regardless of the actual contributions of those members. These rules would also suggest a zero correlation between one's contributions and the contributions of others.

A second set of theories of pure or impure altruism suggest a negative correlation between an individual's contribution and other's contributions in this game. In Becker's model, an individual's utility function can depend on another individual's (or group of individuals') welfare. In this case of pure altruism, an increase in the amount contributed to a public good by other members of the group implies a reduction in an individual's own contribution (see Sugden, 1982, p. 346 for a proof). In Andreoni's model of impure altruism, an individual's utility depends on both others' welfare and positively on the amount he contributed (a formalization of the "warm glow of giving"). In this model, an individual's own contributions and the contributions of others are imperfect substitutes.
An increase in the amount contributed to a public good by other members of the group still implies a reduction in an individual's own contribution, although that reduction is smaller than in models of pure altruism (Andreoni, 1989, p. 1451). However, in both models of altruism, one's own contributions and the contributions of others are negatively correlated. Thus our second altruistic hypothesis is that there will be a negative correlation between an individual's own contribution and the contributions of others in his group.6

Finally, Sugden proposes a model of public goods provision and reciprocity. He defines a principle of reciprocity in which individuals contribute the minimum of (1) the least any other member of a group is contributing and (2) the level of contribution he would most prefer that every member of the group makes. By assuming this principle as a constraint on behavior, Sugden derives the existence of (multiple) equilibria. In Result 4 (p. 780) it is shown that an increase in one group member's contribution can result in an increase in others'. This theory is thus consistent with a positive correlation between one's own contribution and the contribution of other members of the group. Our third reciprocity hypothesis predicts a positive correlation between an individual's contributions and the contribution of others in his group.7

All of these models rely on equilibrium behavior and analysis. In particular, each individual chooses his contribution to be a best response to his beliefs of others' contributions. Although beliefs are correct in equilibrium, they are not always so in real life. Thus when we test these three hypotheses we will also test a weaker version of each by examining the correlation between an individual's contributions and his belief of what the other players will do, rather than their actual behavior. These weaker versions are also implications of the theories described above, but have the added advantage that they do not rely on the assumption of correctness of beliefs.

In addition, all these models are models of one-shot behavior. However, in economics experiments subjects seldom play equilibria on their first try. Rather they
adjust their behavior and converge toward equilibria. In order to give these equilibria their best chance, the experimental design involves two 10-fold repetitions of a public goods game. Since the equilibria described above are equilibria of the stage game, they are also equilibria of the finitely repeated game.

The experiment reported in this paper allows us to discriminate between the implications of three classes of theories of the charitable provision of public goods. The first class of theories (self-interested utility maximization and commitment rules) predict no correlation between an individual's contribution and the contributions of others, or his beliefs about them. The second class of theories (pure and impure altruism) predict a negative correlation. Finally the third class of theories (reciprocity) predict a positive correlation.

4. Previous Experiments

A. Voluntary Contribution Mechanisms

Marwell and Ames (1980) were the first to test public goods provision behavior in a (piecewise) linear and pure public good using the voluntary contribution mechanism. They find that when subjects play a one-shot, context-free public goods game they contribute around half their endowment to the public good and consume the rest. However, later research suggests that when subjects play the same public goods game finitely repeated (with a subgame-perfect equilibrium of full free riding), contributions in the first period are similar to those observed in Marwell and Ames, but decrease over time toward the free-riding solution (Isaac, Walker and Thomas, 1984). Although contributions reach their lowest point in the last period of the game, they do not quite reach the equilibrium outcome of full free riding.

In addition, the experiment reported in Isaac et al. suggests that experienced subjects (who have played a public goods game before) contribute significantly less than
subjects for whom the game is their first. Excellent reviews of public goods experiments can be found in Davis and Holt (1994), Chapter 6 and Ledyard (1995).

B. Belief Elicitation

This study tests the weak versions of the hypotheses by eliciting subjects' beliefs about the contributions of their group and comparing those beliefs with their contributing behavior. Previous experiments have attempted to control subjects' beliefs about their group's behavior rather than to elicit them. For example, in an economics experiment Weimann (1994) deceived subjects about the past contributions of others in their groups. Subjects are told either that everyone else in the group has contributed high (89.75% of endowment) or low (15.75% of endowment). Weimann finds that subjects match their contributions to the manipulated feedback in the low condition; but in the high condition, play is the same as in the control (no manipulated feedback). This asymmetry is consistent with the reciprocity hypothesis in one direction and with the free riding hypothesis in the other.

In addition a number of psychology experiments examine the relationship between beliefs and harvesting behavior in common pool resource games. Schroeder et al. (1983) and Messick et al. (1983) provide manipulated feedback to subjects about the depletion of a common pool and suggest a positive relationship between a subject's own harvest and his manipulated belief of the past harvests of others, consistent with the reciprocity hypothesis. However, in a different study Poppe and Utens (1986) find that subjects contribute less when the pool is increasing and more when the pool is decreasing or remaining constant, consistent with the altruistic hypothesis.

There is also a large literature in psychology on belief elicitation and manipulation in prisoners' dilemma games, which is, on the whole, consistent with the reciprocity hypothesis. Subjects who report believing their counterpart will cooperate in the prisoner's dilemma cooperate themselves, while subjects who report believing their partner will defect, defect themselves.8
In contrast to this previous literature, in the experiment presented in this paper, no deception is used. Instead, players’ beliefs of other players’ behavior are elicited and compared to the players’ own contributions.\textsuperscript{9}

5. Experimental Design and Procedure

This experiment involved 24 subjects arranged in six groups of four. Twelve subjects participated in each of two sessions, thus although subjects could recognize the other participants in the room they did not know exactly which individuals were in their groups. Subjects were paid a five dollar show-up fee along with their earnings in the experiment. Average earnings were $14.30 (plus the $5 fee) for less than an hour of experimental time. The entire experiment was computerized; instructions were given through the computer screen; subjects entered their contribution decisions through the keyboard and, at the end of each period, feedback about their earnings was displayed on the screen.

Subjects played two ten-period voluntary contribution mechanism games.\textsuperscript{10} Each period was divided into an estimation stage and a contribution stage. In the estimation stage, subjects estimated the total number of tokens the other three members of their group would contribute to the group account in the upcoming contribution stage.\textsuperscript{11} Subjects earned 50¢ if their estimate was exactly right. If their estimate was a bit off, they earned 25¢ divided by the (absolute) distance between their estimate and the true contribution.\textsuperscript{12}

In the contribution stage of the game, each subject was endowed with 25 tokens which could be allocated either to a private account, which paid 2¢ per token to the individual only, or to a group account (the public good), which paid 1¢ per token to each of the four members of the individual’s group. At the end of each period, subjects were reminded of their own estimate, told the true contribution of the other three members of
group, the total group contribution and their earnings from both the estimation stage and the contribution stage.

Each period of this experiment incorporates a pure public goods problem. Under traditional assumptions of self-interest, regardless of the decisions of the other players, each individual strictly prefers to place all of his tokens in his private account, earning 2¢ per token, than in the group account, earning 1¢ per token. However the group as a whole earns 4¢ when a token is placed in the group account (1¢ to each of the four members) but only earns 2¢ when the token is placed in a private account.

6. Results

A. Hypothesis Testing

The hypotheses outlined above and their weak versions provide testable predictions about the relationship between an individual's contribution and the contributions of the rest of their group and between individual's contributions and their beliefs about what others in their group will contribute. To test these hypotheses we run two random effects model GLS regressions on individual contributions. Random effects models control for individual-specific effects (Greene, 1990).

The first regression tests the original versions of the three hypotheses, by comparing an individual's contribution with the actual contribution of the rest of his group. The dependent variable is the individual's contribution to the public good. independent variables are the ACTUAL contributions of the other three members of his group, the PERIOD number to control for intertemporal effects, a dummy variable for the SECOND game and dummy variables for each group. The regression is stratified by individual. Results of the regression are reported in Table 1.13

Table 1 about here
This regression reports a significant positive correlation between a subject's contribution and the contribution of the other three members in his group. This positive correlation provides support for the reciprocity hypothesis and against both the free riding hypothesis and the altruistic hypothesis.

In addition, this analysis extends two previous results from the experimental literature. First, we see declining individual contributions over time (controlling for actual contributions of other group members) with a significant negative coefficient on the period number variable. Second, contributions are significantly lower in the second game as subjects gain experience with the public goods problem.

A second random effects regression tests the weak versions of the three hypotheses, and compares an individual's contribution with his belief of what the rest of his group will contribute. The dependent variable is an individual's contribution to the public good, independent variables are the individual's GUESS of what the other three members of his group will contribute, the PERIOD number and the same dummy variables as above. Results of the regression are reported in Table 2.\textsuperscript{14}

---

Table 2 about here

---

This regression reports a significant positive relationship between a subject's guess of what the other three members of his group will contribute and his own contribution. This positive correlation supports the weak version of the reciprocity hypothesis.

As in the earlier regression, group-specific effects are generally not significant. In contrast, period effects and the effects of the second game were also nonsignificant in this regression. This result suggests that subjects' guesses are accurate in the sense that they take these trends into account. The next section provides evidence on the accuracy of subjects' guesses.
The data from this experiment support the reciprocity hypothesis over either the free riding hypothesis or the altruism hypothesis. A significant positive relationship is found between an individual's contribution and the contribution of others to a public good. A similar relationship is found between an individual's contribution and his belief of the contribution of others.

B. Estimate Accuracy

Each subject estimated what others in his group would contribute to the group account. One interesting question involves the accuracy of these estimates.

Figure 1 shows the average absolute estimation error made by each group in each period of the game. This error is calculated by computing the absolute error of each subject in each period (the distance between their guess and the other three subject's actual contributions) and averaging within each group. If all subjects were extremely bad guessers this average absolute estimation error could be as high as 75. Instead subjects appear to be fairly accurate in their estimations of others' behavior.

We can define a given subject's estimation error as the difference between that subject's estimate and the actual contributions of the other members of his group. Over all ten rounds of the first game, eight out of 24 subjects exhibited significantly positive levels of error (overoptimism). In the second game, no subjects exhibited significant levels of error.15 Throughout the experiment, most subjects provided unbiased guesses of what their counterparts in the public goods game will do. This accuracy provides indirect but not conclusive evidence against the similarity hypothesis hypothesized by Dawes et al. (footnote 8).
7. Discussion and Conclusion

The experiment reported in this paper tested comparative statics predictions of three models of voluntary public goods provision. The results support the reciprocity model in which individual contributions are positively related to the contributions of others, or to their beliefs about those contributions.

Reciprocal behavior is also supported by anecdotal evidence. Charities eliciting contributions often suggest a particular level as the "standard" gift or report the size of their "average" contribution. Presumably this influences individual's beliefs of what others are giving, thus causing them to give more.

Even the very wealthy seem to exhibit reciprocal behavior, in this example from Forbes Magazine, "Seattle's Lakeside Upper School counts ... Bill Gates among its alumni. Rumor has it a fundraiser for the high school put the bite on Gates, who asked: ‘How much is everyone else giving?’ About $75 he was told. ‘So put me down for $75,’ said Gates.” (p. 18).

While matching behavior like this is consistent with the reciprocity principle, it may be adaptively rational as well. If the quality or reliability of charitable groups are not known, individual contributors may use the contributions of others as a signal for how much they should contribute themselves. Alternately, such a principle might be evolutionarily stable. Societies whose members follow this principle are more likely to be able to supply public goods than societies whose members practice self-interest utility maximization.

This study examines the factors that motivate individuals to make contributions to public goods and charities which provide them. In particular, it finds support for Sugden's reciprocity theory over altruistic theories of Becker (pure) and Andreoni (impure), traditional free-riding theories and commitment theories of Laffont, Collard and Harsanyi. We find a significant positive relationship between an individual's contribution and the contribution of the rest of his group, as well as between an individual's contribution and his belief about the contribution of the rest of his group. These results suggest that part of a player's objective may be to match the contributions of other members.
References


Footnotes

1The actual amount contributed by individuals in 1995 was $116,230,000,000. This number excludes charitable giving by corporations, foundations and bequests.

2For example see Olson (1971) and Groves and Ledyard (1977), for mechanisms which force individuals to contribute toward the provision of public goods once desired quantities are known. In addition, Guttman (1978) describes a two-stage mechanism of matching which can implement pareto-optimal contribution levels.

3That is, multiple agents can consume the good at the same time (nonrival) and it is not possible to exclude agents who did not pay for the good from consuming it (nonexcludable).

4The multiple P is often called the marginal per capita return (MPCR) and is the marginal return to each individual on a contribution of one unit to the group account.

5This result follows trivially from utility maximization in the specification of the problem above.

6Other theories of altruism also predict this negative correlation (e.g. Schwartz, 1970; Arrow, 1975; Hood, Martin and Osberg, 1977; Sen, 1977; Margolis, 1982; Roberts, 1984; Posnett and Sandler, 1986).

7A similarly positive correlation has been assumed in theories of voluntary activities (e.g. Cornes and Sandler, 1984).
'Dawes et al. (1977) suggest that a similarity bias is involved: cooperative subjects believe others will be like them and cooperate, while competitive subjects believe others will be like them and compete. Here, subjects' beliefs are a function of actions taken, rather than actions taken being a function of subjects' beliefs. Unfortunately, the experiment presented here provides no direct way to separate the correlation from the causality of the issue. Some indirect evidence, however, may be useful. If the similarity bias is the cause of a positive correlation, we might expect predictions about others' behavior to be far away from their true behavior (since the estimates are based only on one's own actions). However the estimates provided by the subjects are quite accurate, see section 6B below.

A similar technique of belief elicitation has been used in public goods games in different contexts. In Isaac and Walker (1992) and Dudley (1993), voluntary contribution mechanisms are run which have interior Nash equilibria (rather than a boundary equilibrium). Both studies elicit subjects' beliefs about others' behavior and categorizes subjects based on whether they play best responses to their own beliefs. Offerman, Sonnemans and Schram (1994) elicit subjects' beliefs about others' behavior in a game with binary contributions and step-level public goods.

In addition there were three practice periods before the first game began to familiarize subjects with the computer program and the process. Subjects were not paid their earnings during the practice periods and no practice periods were run before the second game. Raw data as well as the instructions used are available from the author.
Because they estimated the contributions of the other three members of the group, subjects could not influence the accuracy of their guess by strategically changing their own contribution.

This payment scheme leads to an approximation of a single-peaked curve. Thus subjects have an incentive to guess their true belief.

The same regression excluding dummy variables for each group had similar results, with the exception of a significant constant term. A two-factor random effects model regression, which controls for both individual effects and for time effects in the error term, but excludes PERIOD as an independent variable also produces similar results.

The same regression excluding dummy variables for each group had similar results, as did a two-factor random effects model regression excluding PERIOD.

The hypothesis that the mean of the distribution of errors in the first game is equal to zero can be rejected at the 5% level for eight out of 24 subjects. It cannot be rejected for any subjects in the second game.
Table 1

Individual Contributions and Other's Contributions

<table>
<thead>
<tr>
<th>Contributions</th>
<th>Coefficient</th>
<th>SE</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTUAL</td>
<td>0.1223</td>
<td>0.0207</td>
<td>5.9092</td>
<td>0.0000</td>
</tr>
<tr>
<td>PERIOD</td>
<td>-0.2790</td>
<td>0.0774</td>
<td>-3.6026</td>
<td>0.0003</td>
</tr>
<tr>
<td>SECOND</td>
<td>-1.9685</td>
<td>0.4586</td>
<td>-4.2920</td>
<td>0.0000</td>
</tr>
<tr>
<td>Constant (Grp1)</td>
<td>3.9669</td>
<td>1.8807</td>
<td>2.1093</td>
<td>0.0349</td>
</tr>
<tr>
<td>Grp2</td>
<td>2.5658</td>
<td>2.4683</td>
<td>1.0395</td>
<td>0.2986</td>
</tr>
<tr>
<td>Grp3</td>
<td>0.7913</td>
<td>2.4631</td>
<td>0.3213</td>
<td>0.7480</td>
</tr>
<tr>
<td>Grp4</td>
<td>2.2318</td>
<td>2.5330</td>
<td>0.8811</td>
<td>0.3783</td>
</tr>
<tr>
<td>Grp5</td>
<td>0.2058</td>
<td>2.5236</td>
<td>0.0815</td>
<td>0.9350</td>
</tr>
<tr>
<td>Grp6</td>
<td>0.1108</td>
<td>2.5235</td>
<td>0.0439</td>
<td>0.9650</td>
</tr>
</tbody>
</table>
Table 2

Individual Contributions and Guess about Other's Contributions

<table>
<thead>
<tr>
<th>Contributions</th>
<th>Coefficient</th>
<th>SE</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUES</td>
<td>0.1998</td>
<td>0.0145</td>
<td>13.7976</td>
<td>0.0000</td>
</tr>
<tr>
<td>PERIOD</td>
<td>-0.1009</td>
<td>0.0666</td>
<td>-1.5146</td>
<td>0.1299</td>
</tr>
<tr>
<td>SECOND</td>
<td>-0.0781</td>
<td>0.4177</td>
<td>-0.1870</td>
<td>0.8522</td>
</tr>
<tr>
<td>Constant (Grp1)</td>
<td>0.6255</td>
<td>1.9488</td>
<td>0.3210</td>
<td>0.7482</td>
</tr>
<tr>
<td>Grp2</td>
<td>2.2163</td>
<td>2.5388</td>
<td>0.8730</td>
<td>0.3827</td>
</tr>
<tr>
<td>Grp3</td>
<td>0.6740</td>
<td>2.5482</td>
<td>0.2645</td>
<td>0.7914</td>
</tr>
<tr>
<td>Grp4</td>
<td>1.3019</td>
<td>2.6443</td>
<td>0.4923</td>
<td>0.6225</td>
</tr>
<tr>
<td>Grp5</td>
<td>0.1601</td>
<td>2.6394</td>
<td>0.0607</td>
<td>0.9516</td>
</tr>
<tr>
<td>Grp6</td>
<td>0.7071</td>
<td>2.6397</td>
<td>0.2679</td>
<td>0.7888</td>
</tr>
</tbody>
</table>
Figure 1
Average Absolute Estimation Errors

Number of tokens

Period #

■ Group 1 □ Group 2 ● Group 3 ◊ Group 4 ▲ Group 5 △ Group 6