Resolving a Public Good Dilemma using Reward and Sanction Mechanisms.

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Abstract

This study investigates the effect of reward and sanction mechanisms on contributions to a public good fund in an experimental context. Thirty-six participants were recruited from a first year economics course, based on their responses to a trust questionnaire. They participated in an experiment in which they were asked to contribute funds to public and private accounts. In addition, they were asked in the experimental conditions to contribute to a reward fund, a sanction fund, or both. The results of the experiment were that while both sanction and reward mechanisms were equally effective at inducing participants to contribute to a public good fund, the presence of a reward mechanism is critical in raising participant profits. No effect of trust on contributions or profit was found, but this may be due to a small sample pool.

1. Introduction

The public good problem has received considerable attention in the literature.[1] The present paper provides a test of two methods (sanction and reward) of inducing compliance and examines how contribution behaviour and final outcomes are affected by these methods. The results of the study suggest that while sanctioning and rewarding are equally effective at increasing contributions, only the reward mechanism raises participant earnings.

The outline for this paper is as follows. Section 2 provides a review of some of the experimental results. Section 3 sets out the hypotheses, experimental design and procedure. Section 4 presents the findings of the study, while Section 5 concludes.

2. Nature of the Problem and Literature Review

A public good is non-rival and non-excludable. This means that one person's consumption does not affect others and that it is possible to consume the good without paying for it ('free-ride'). A rational individual will choose not to contribute towards the good's provision but free-ride on the contributions of others. If every individual chooses to behave in this way, the public good will not be provided, leaving everyone worse off. However, there is much evidence in experimental studies to show that contributions in public goods games exceed zero for many individuals, though may fall far below an optimal level of contributions (Ledyard, 1995).

Results from Dictator and Ultimatum games,[2] which are simple games that focus on rationality and self-interest, also challenge the 'narrow self-interest assumption', that "more money for myself is always preferred to less" (Bolton, 1998; p263-264). Dictators often give more than zero to the recipient. The first player in an ultimatum game tends to offer around 40% of the total amount of money, and the second player tends to reject any offer much lower than this (Bolton, 1998). Textbook microeconomic theory would predict a dictator giving zero to the recipient, while in an ultimatum game, the prediction would be for the first player to offer a small fraction (slightly above zero) to the second player, and for the second player to accept this offer.

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[1] See, inter alia Davis and Holt (1993), Ledyard (1995) and Komorita and Parks (1996).

[2] In a dictator game, the 'dictator' is given a sum of money and chooses how much to give to another player. The obvious theoretical outcome would be for the dictator to give nothing to the other player. In an ultimatium game, the first player is asked to divide up a sum of money between himself and another player. If the second player accepts the offer, then they each get the portion that they have agreed to. If the second player refuses the offer, both players get nothing.

Personality factors may help provide an explanation of this 'irrational' behaviour. One such factor is trust. Trust can be defined as "the willingness of a party to be vulnerable to the actions of another party based on the expectations that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayerm Davis and Schoorman, 1995; cited in De Cremer, D., Snyder, M., and Dewitte, S., 2001). Evidence suggests that significant differences in contributions exist between high and low trusters in a public goods dilemma (Yamagishi, 1986, 1988b; Parks, 1994; De Cremer, et al., 2001).

One of the main solutions proposed to the public goods problem is the use of a compliance mechanism of some form to induce individual contributions. There is evidence to show that individuals may choose voluntarily to contribute to a sanctioning system to help resolve a public goods dilemma (Yamagishi, 1986, 1988a, 1988b; Fehr & Gachter, 2000). This suggests that individuals do care about maximising collective outcomes, but fear that their cooperative behaviour will be exploited (Yamagishi, 1986; Fehr and Gachter, 2000). Parks and Hulbert (1995) found that the impact of trust on cooperation depended upon whether fear (of not receiving a payoff from contributing) was present in the social dilemma. When fear was present, as is usually the case in a public good dilemma, low trusters cooperated less than high trusters. When fear was absent, high and low trusters displayed similar levels of cooperation.

However, a voluntary sanctioning system is not necessarily a straightforward solution, as it is itself a public good (Yamagishi, 1986, 1988a); "the provision of such a sanctioning system creates another social dilemma because the benefit of such a system is available to all members whether or not they contribute to the introduction of such a system change" (Yamagishi, 1988a; pp. 33). Yamagishi defined such a voluntary system as a 'second-order' public good. If individuals who free-ride in the original dilemma free-ride in the second order dilemma, then any 'system change solution' must come from an external source (Yamagishi, 1988a).

Yamagishi (1986) found that high trusters would contribute more than low trusters in the standard public good problem. To resolve the dilemma, he found evidence that sanctioning could be effective: low trusters not only contributed more to a sanctioning fund than high trusters, but also contributed more towards the public good in the presence of a sanctioning fund, compared to when the sanctioning fund was unavailable. Yamagishi later undertook a similar experiment using American college students (Japanese college students were used in the 1986 study), and reached similar conclusions (Yamagishi, 1988b). Yamagishi also found evidence of cultural differences between American and Japanese

college students. American college students scored higher in trust, and cooperated more than Japanese college students, when sanctioning was unavailable.

An unrelated study by Cason, Saijo and Yamato (2002) using a different public good game set-up reported a result along similar lines.[3] They found that Japanese college students were more likely than their American counterparts to act spitefully or punish 'non-participants'[4] in public good games.

Falkinger (1996) proposes a simple mechanism as a solution to the public good problem. Essentially, deviations from average contributions are rewarded or sanctioned. This mechanism has had success in an experimental context in raising public good contributions and has the advantage of being self-funding (Fakinger, Fehr, Gachter, and Winter-Ebmer, 2000).

Publicising information relating to participant contributions can also have an effect. A study by Clark (1999) found that revealing the maximum contribution made in each trial led to a slight, but significant, increase in average contributions. Clark also found no effect on contributions from allowing other participants to reward the largest contributor to the public good. The result of Clark's (1999) study was that while rewarding increased contributions, publicising information relating to maximum contributions alone achieved a similar result.

3. The Design of the Present Study

The experiment has two aims. First, to investigate differences between contributions to a public good fund based on trust and gender. Second, to investigate the effects of a voluntary reward or sanctioning mechanism on contributions and profits in a public good dilemma. There are four hypotheses in this study:

1) There will be no gender difference in contributions to the first order public good across conditions.
2) There will be significant differences in contributions between high and low trusters in the control condition.
3) Contributions to the public good will be higher in the presence of a second order public good.

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[3] This study did not consider interpersonal differences relating to trust. Also, its set-up was a repeated one-shot game such that no two participants played each other twice. Hence, in contrast to Yamagishi's study there should be no motivation for 'sanctioning' as it should not affect the behaviour of the completely new participant one would be interacting with in the next period.

[4] This experimental set-up involved an initial decision on whether to 'participate' in the provision of the public good, followed by a decision on how much to contribute by those who choose to participate. Essentially, a decision not to participate is an "announced commitment to free-ride on the other's contributions" (Cason et al., 2002; p 134).

4) Profits for individuals will be higher in the presence of a second order public good.

Participants

Thirty-six participants who were undertaking a stage one economics course at the University of Otago were chosen based on their responses to a pre-experimental questionnaire. Participants were recruited through lectures and asked to fill in the questionnaire if they were interested in participating. The questions used were the same as those used by Yamagishi (1986). Responses were used to classify particpants as high, medium or low trusters, forming a pool of 124 potential participants. Eighteen males and eighteen females participated in this study, their ages ranging from 18 to 25 years old. The selected participants were split into nine groups of four participants, with each group matched by gender and trust, such that each group was comprised of one male and one female high truster, and one male and one female low truster. Where possible, care was taken to schedule groups such that no two participants known to each other participated in the same group. Trust level was determined by summing the trust scale values, higher total values indicating higher trust. Low trust participant scores ranged from 9 to 16, with a mean of 14. High trust participant scores ranged from 20 to 27, with a mean of 24. The questionnaire was carried out about two weeks before the experiment, in order to limit any effect that the subject's response to the questionnaire might have on his/her behaviour. Participation was voluntary, but participants were financially remunerated.

Design

The experimental design is a mixed, 2x2x2x2 factorial design, with nine groups. This design can be decomposed as follows. There are two between-subject factors, with two levels to each factor: Trust (low and high) and Gender (male and female). There were also two within-subject factors, each factor also having two levels: Reward fund (available, not available) and Sanction fund (available, not available). In each within-subjects condition (Control, Reward, Sanction, Reward and Sanction) the first 15 trials were used in the analysis. Counterbalancing was used between the sanction and reward conditions; five of the groups undertook the sanction condition in the second round, while the other four groups undertook the reward condition in the second round. All participants undertook the control condition in the first round, and the sanction and reward condition in the fourth round. The manipulated variables in the study were whether subjects had the option to contribute to a sanction fund, a

reward fund, both or neither. The measured variables for each participant were contributions to the public fund and profits (or earnings) per trial. The nine experimental sessions took place at the Economics Department of the University of Otago during August 2003.

Participants who had been selected were given an information sheet (see Appendix A) prior to the experiment outlining the nature of the public goods dilemma they were to participate in. They were not given information about strategies. Upon arrival at the laboratory, individual participants were taken to an isolated room away from the other members of their group to prevent contact. This was to try to capture the effect of anonymity present in many real world public goods dilemmas. Each room had a computer, with the public goods game client software Zleaf installed. Zleaf is part of the Ztree program, designed by Urs Fischbacher at the University of Zurich (Fischbacher, 2002). Participants were paid NZ$5 as a 'show-up' fee for turning up to the experiment. Participants were also be told that they would be given a proportion of their earnings, based on their performance in the experiment, to a maximum of NZ$30.

In the initial control condition, subjects were given 150 cents to allocate between a private and public account. They were informed that if total contributions to the public account exceeded 300 cents then this amount would be doubled and distributed equally amongst all the four subjects in the group. If contributions were less than this then the public good would not be provided, and all contributions to the public account in that round would be lost. This was done to capture the effect that public goods are generally costly to build but once built are available for use by all. Any contribution to the participant's private account would be for that individual only.

In the experimental conditions, subjects were given the opportunity to contribute to a reward system, a sanction system, or both (in addition to the public and private accounts). All contributions to the reward account were doubled and added to the earnings of the highest contributor to the public good in that round. All contributions to the sanction account were doubled and subtracted from the earnings of the lowest contributor to the public good in that round. The rewards or sanctions were given out regardless of whether or not the public good was provided. In the event of a tie, the reward or sanction was shared out between the winners or losers. There were two to five practice trials for each condition. At the conclusion of the last round, participants were debriefed, given information relating to the collection of their earnings, thanked and dismissed.

4. Results and Discussion

Contribution

No overall main effect of gender ($F(1,32)=2.77$, $p=0.106$) or trust ($F(1,32)=0.09$, $p=0.766$) was found on contributions over all the conditions. These results supports the first hypothesis that there would be no difference between males and females on contributions to the first order public good, but not the second hypothesis, that there would be differences in contributions between high and low trusters. This suggests that the groups may have been composed only of moderate trusters, rather than of distinct groups of high and low trusters. The most likely explanation for the non-significant results was that the initial scheduling was changed to accommodate withdrawals and participant availability. While the replacement participant was always of the identical gender as the initial participant, it was not usually possible to find a replacement with an identical trust score as well.

[Insert *Figure 1*. Mean contribution in each condition, for males and females.]

The trust by gender interaction was non-significant ($F(1,32)=2.00$, $p=0.167$). Given the non-significance of trust and gender overall, analysis was done on overall mean contributions in each condition. The differences in mean contributions between the reward, sanction, reward and sanction conditions were not significant as all the differences were within two standard errors. The difference between mean contributions in the control condition and each of the three experimental conditions was greater than two standard errors in each case. In order to assess whether these differences were statistically significant, the Student-Newman-Keuls (SNK) test was conducted.[5] The SNK q test found there were significant differences between mean contributions in the control condition and each of the three experimental conditions. This suggests that the source of the significant reward by sanction interaction ($F(1, 96)= 11.86$, $p<0.01$) is due to a significant difference between mean contributions in the control condition with mean contributions in each of the experimental conditions. With respect to the experimental conditions, a significant main effect of the reward factor ($F(1,96)=16.44$, $p<0.01$), as well as a significant main effect of the sanction factor ($F(1,96)=13.18$, $p<0.01$) was found. These results show that the reward or sanctioning mechanism (second order public good) was effective at raising contributions to the first order public good. This finding supports the third hypothesis: the second order public good had a

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[5] The procedure of the SNK is outlined in Zar (1974).

significant and positive effect on contributions to the first order public good in the present study. In fact, the presence of a second order public good always induced greater contributions to the first order public good. This effect was present for both genders and consistent over trials (Figures 2 and 3).

In summary, the overall effect of all the experimental conditions (second order public goods) was to increase contributions to the (first order) public good. There were no significant differences amongst the experimental conditions; the reward and sanction mechanisms were equally effective at raising contributions.

[Insert *Figure 2*. Mean contribution in each trial by males.]

[Insert *Figure 3*. Mean contribution in each trial by females.]

A significant four way linear interaction between trials, gender, reward and sanction ($F(1,1792)=6.04$, $p=0.014$) was also found. Examination of this interaction suggests that the reward and sanction conditions together have a significant effect on contributions across trials, and that this effect differs between genders. In the control condition (Figure 4a), male contributions start off higher than female contributions. Over trials, female contributions remain steady, but there is a decline in male contributions. In the reward condition (Figure 4c), the male and female contributions are similar over the initial trials. Male contributions do not change much over trials, but female contributions decline over trials. Note that this is the opposite effect for the opposite gender, compared to the control condition discussed previously. There is little gender difference in the sanction condition (Figure 4b), or the reward and sanction condition (Figure 4d). These variations in contribution trends are significant.

[Insert *Figure 4*. Mean contributions in each trial, for each condition (left-to-right, top-to-bottom): control, sanction, reward, reward and sanction.]

Profit

No overall main effect of gender ($F(1,1792)=0.01$, $p=0.918$) or trust ($F(1, 1792)=2.51$, $p=0.123$) was found on profit over all of the conditions. The trust by gender interaction was also non-significant ($F(1,1792)=0.34$, $p=0.561$). As trust and gender were not significant, mean profits across conditions were pooled. The differences in mean profits between the control and sanction conditions, and between the reward and reward and sanction conditions were not significant. In both cases, this was because the difference between these means was

within two standard errors. To assess whether the differences in mean profits were significantly different where differences were greater than two standard errors, the SNK q test was conducted at the α = 0.01 level of significance. The results of this test found that mean profits in the control and sanction conditions were significantly different from those in the reward condition, and also those in the reward and sanction condition. However, mean profits in the reward and sanction condition were not significantly different to that in the reward condition, nor were significant difference in mean profits between the control and sanction conditions found.

The key implication of these results is that the reward mechanism is critical to raising profits in the present study. Profits are significantly lower in the absence of a reward mechanism (control or sanction conditions), while the addition of the sanction mechanism has no effect on profits. The ineffectiveness of the sanction mechanism is shown by the absence of a significant difference between mean profits in the reward condition and mean profits in the reward and sanction condition, as well as between the control condition and sanction condition.

[Insert *Figure 5*. Mean profit in each condition, for males and females.]

With respect to profit, a significant four way linear interaction between trials, gender, reward and sanction was found ($F(1,1792)=8.55$, $p=0.004$). Examination of Figure 6a shows that profits fall over trials, and that this decline is greater for females than males. By contrast, in Figure 6b, profits increase over trials, and this increase is greater for females than males. In Figure 6c, profits decline over trials, and this decline is greater for males than females. Note that this trend is the opposite to that in Figure 6a. Finally, in Figure 6d, there does not appear to be any apparent change in profits over trials. This is different to the result in 6b and 6c. These variations in profit trends are significant and differ with respect to gender. These results support hypothesis four, that the second order public good would have a positive effect on profit.

[Insert *Figure 6*. Mean profits in each trial, for each condition (left-to-right, top-to-bottom): control, sanction, reward, reward and sanction.]

5. Discussion

One of the main limitations of this study is the small sample size. The lack of significance on the effect of trust should not be taken as a rejection of the trust scale used. It appears that in order for the trust scale to be effective, it requires a large sample size in order

to have large enough tails from which to draw participants. The participants in the study could be seen as moderate trusters, rather than two distinct groups of high and low trusters.

An interesting observation was that there appeared to be a significant cultural discrepancy with respect to trust score responses in the initial questionnaire. Scores on the trust scale from Asians (based on surnames provided) tended to be high, with relatively few low scores. This is somewhat surprising as Yamagishi (1988b) found that Japanese college students had lower trust than American college students, and this result could be regarded as a good proxy for Asians in general.

The significance of gender on behaviour over trials suggests that changing the gender ratio in the groups could have an effect. All groups in the present study were composed of two males and two females. An interesting future study could be to see what effect gender composition of groups alone can have on contributions to the public good.

The significance of the linear interactions and absence of significant quadratic interactions suggests that participant behaviour is still changing over trials, and has not settled down to some sort of stable equilibrium. A limitation of this study may be that there were not enough trials in order to see if behaviour settles down over time. The significance of the linear interactions also suggests that a meaningful study of contributions to the second order public good funds would not be feasible in the present study. A test of the effect of contributions to a second order public good fund itself would require stable behaviour, in a more controlled setting.

One final point should be made about a potential design improvement. In reality, most major economic decisions, such a buying a house or a car are made not by individuals, but by households, or groups of individuals. The current study looks at individuals in isolation, yet perhaps future studies should investigate group decision making in the public good problem.

In conclusion, the key result of the study is that a second order public good is effective at raising contributions to the first order public good, which is consistent with the previous literature. However, while both second order public goods are effective at raising contributions, it is only in the presence of a reward mechanism that profits increase relative to the control condition. The results of the study show that the sanctioning mechanism on its own does not significantly increase profits, nor does the sanctioning mechanism interact with the reward mechanism to increase profits beyond what the reward mechanism could achieve by itself. So while individuals respond equally well to a reward or sanctioning mechanism, the sanctioning mechanism in isolation does not improve individuals' welfare compared to when no second order public good is available. In the present study, the availability of the reward mechanism is crucial to raising both individual contributions and profits.

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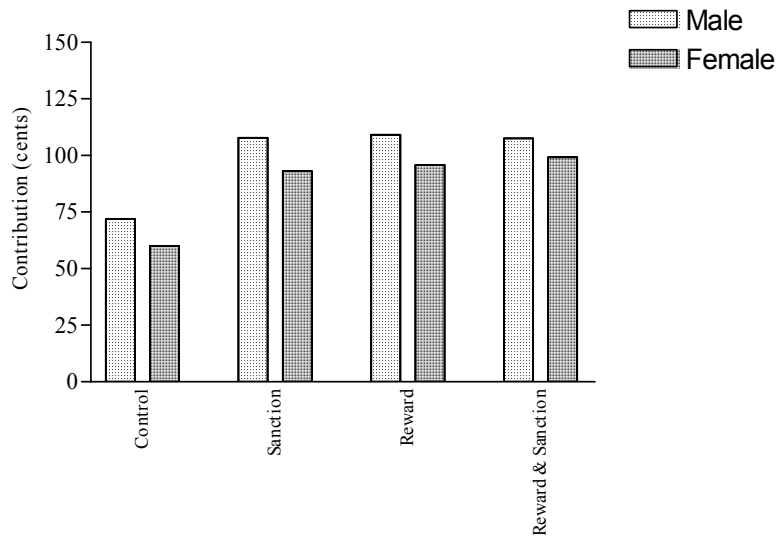Zar, J.H. (1974) *Biostatistical Analysis*. Englewood Cliffs, New Jersey:Prentice Hall.

Figure 1. Mean contribution in each condition, for males and females.
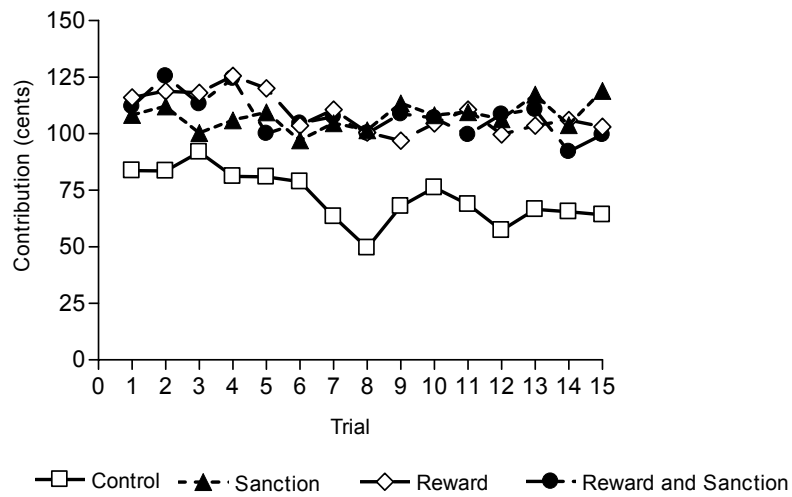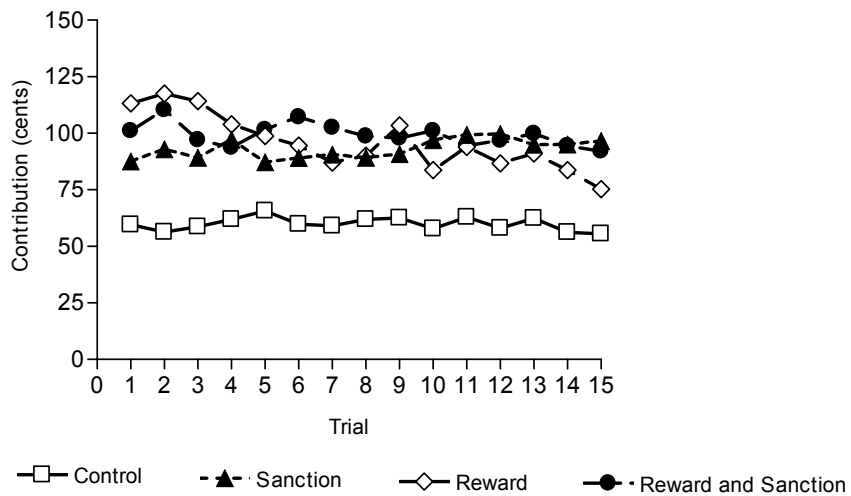

Figure 2. Mean contribution in each trial by males.

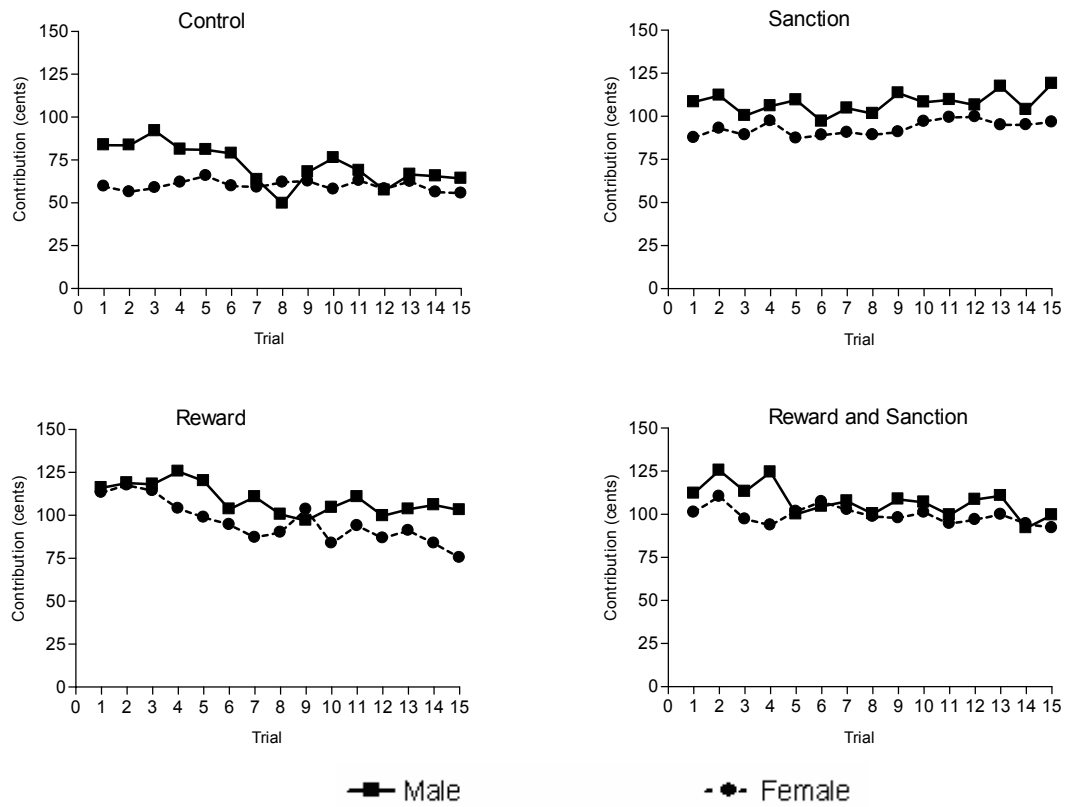*Figure 3.* Mean contribution in each trial by females.

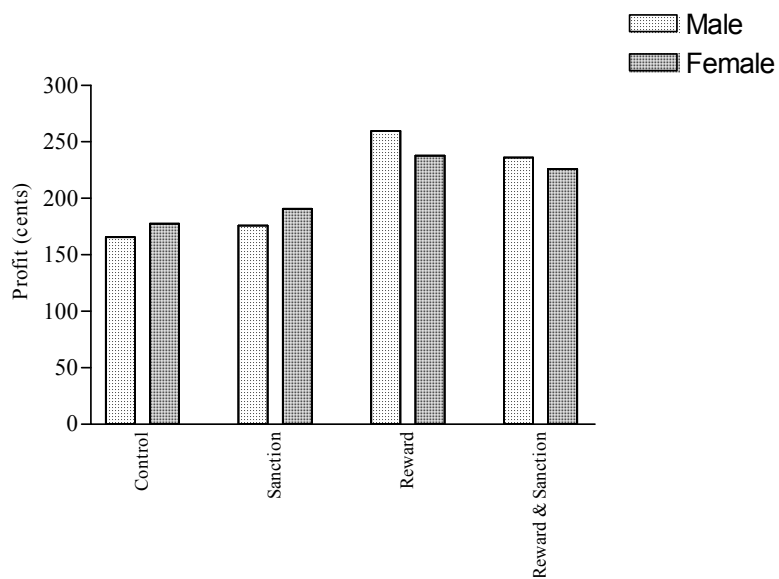*Figure 4.* Mean contributions in each trial, for each condition.

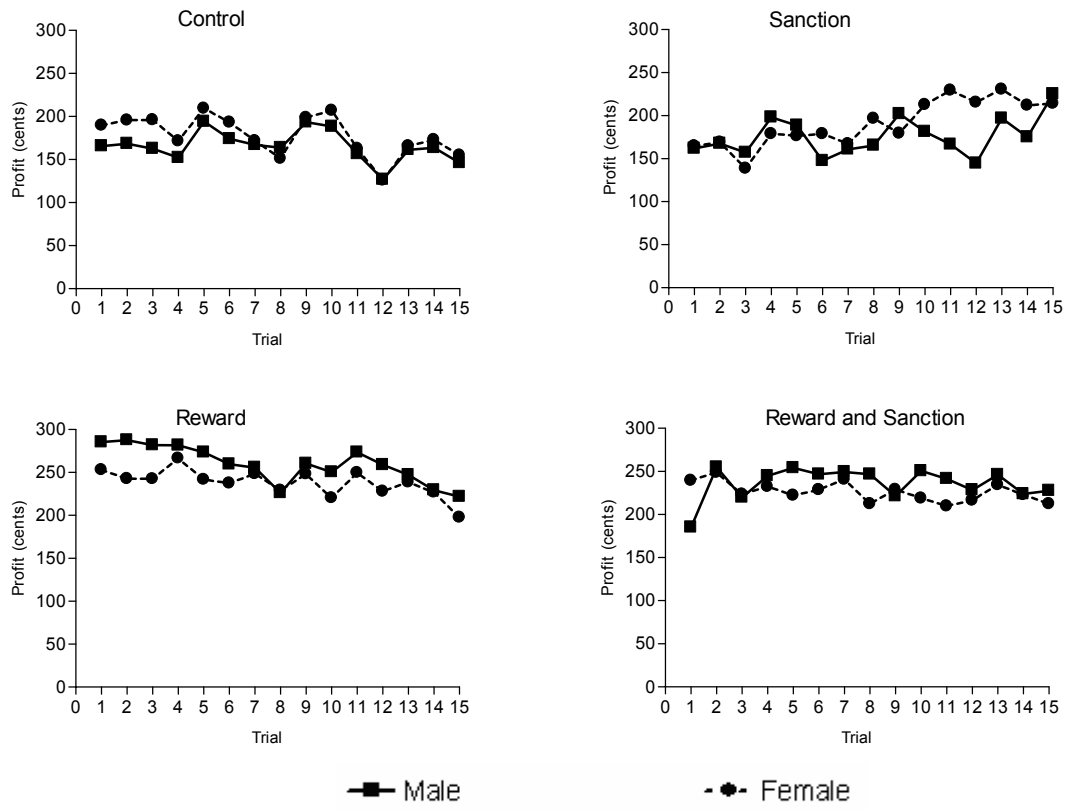*Figure 5.* Mean profit in each condition, for males and females.

Figure 6. Mean profits in each trial, for each condition.

8. Appendix A

Resolving a Public Good Dilemma through Sanctioning or Rewarding
INFORMATION SHEET FOR
PARTICIPANTS.

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you of any kind and we thank you for considering our request.

What is the Aim of the Project?

This study is being undertaken as partial requirements for the Bachelor of Commerce (Honours) Degree.

The aim of the study is to investigate factors affecting individuals' contributions to a public good, and whether the availability of a punishment or reward system will affect an individual's contribution to a public good.

What Type of Participants are being sought?

Participants who will be undertaking ECON102 this semester are being sought, regardless of age or sex.

What will Participants be Asked to Do?

Should you agree to take part in this project, you will be asked to fill out a questionnaire. The results of this questionnaire will be used to select the participants for this experiment. This questionnaire is expected to take around two minutes.

If you are one of the participants who has been selected, and agree to partake in the study, you will be asked to undertake a random number of trials between 12-22 in each of the four stages of the experiment. In each trial you will be give 150 (experimental) cents and asked how many cents you wish to contribute towards a public good fund, your own private good fund and in experimental conditions how much you would also like to contribute to a sanction (punishment) fund, a reward fund or both, (with any remaining funds being kept in your private account). At the end of each trial, you will be given information relating to your contributions to the various funds and the total contributions to the various funds. The entire experiment including debriefing will be done in around an hour.

You will receive a $5 "show-up" payment for turning up to the experiment. In each trial you will be allocated 150 (experimental) cents to distribute to a series of accounts; A public account, where all contributions are doubled and split equally amongst all participants, provided total contributions exceed 300 (experimental) cents, otherwise all contributions to the fund are lost; A private account where your contributions remain unchanged, but will be allocated only to you.

In addition, you may also be asked to contribute to a sanction fund, a reward fund or both (you will be given information at the start of each trial as to whether these options are available to you). All contributions to the sanction fund will be doubled, and subtracted from the earnings of the lowest contributor in that trial round. Likewise, all contributions to the reward fund will be doubled and added to the earnings of the highest contributor in that trial round. You will undertake a random number of trials between 12-22 in each of the four stages. The only source of discomfort in this experiment to you will be exposed to will be any disappointment associated with your earnings not being as high as you perhaps might have liked, or losing some of your earnings for being the lowest contributor in a trial round, when that trial round has a sanction fund.

In addition to receiving $5 from showing up at the experiment, you will be able to keep some funds from your participation in the experiment, up to a maximum of $30.

Please be aware that you may decide not to take part in the project without any disadvantage to yourself of any kind.

Can Participants Change their Mind and Withdraw from the Project?
You may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

What Data or Information will be Collected and What Use will be Made of it?
The results of the questionnaire will be used for initial classification and selection of participants. If you are selected and agree to participate then information will be collected on the following: Your earnings in each trial, your contributions to the public good, your private account, the sanction fund and the reward fund. Similar information will be collected from the other participants as well. The data will be used to conduct statistical tests such as ANOVA (Analysis of Variance).

The data is being collected to examine the effect of different factors on individual contributions to a public good.

The raw data will be collated by the student researcher who will conduct statistical analysis on it, or in the case of the questionnaire used for participant selection. Access to the raw data will be limited to the Student researcher, Supervisor and the Research Assistant of the department.

Results of this project may be published but any data included will in no way be linked to any specific participant.

You are most welcome to request a copy of the results of the project should you wish. The data collected will be securely stored in such a way that only those mentioned above will be able to gain access to it. At the end of the project any personal information will be destroyed immediately except that, as required by the University's research policy, any raw data on which the results of the project depend will be retained in secure storage for five years, after which it will be destroyed.

What if Participants have any Questions?
If you have any questions about our project, either now or in the future, please feel free to

contact either:-

Phillip Hall	or	Dr. Robert Alexander (Supervisor)
Department of Economics		Department of Economics
Email: halph412@student.otago.ac.nz		University Telephone Number:
		(03) 479 8647

This project has been reviewed and approved by the University of Otago Economics Department Academic Board