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Does the Endowment of Contributors Make a Difference in Threshold Public Games?

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Abstract

We investigate experimentally whether the endowment of potential contributors changes the success rate of providing threshold public goods. We find a U shaped relationship in which the success rate is relatively high when the endowment is either relatively small or large. We also find an inverted U shaped relationship in terms of the variance of contributions. This suggests that people find it hardest to coordinate and provide threshold public goods when endowments are of 'intermediate' size. By this we mean that the endowment is small enough that people do need to contribute relatively a lot to fund the good, but is also large enough that no one person is critical in providing the good. Coordinating is difficult in this case because there is an incentive to free ride and the possibility to do so creating a conflict of interest.

1. Introduction

A threshold public good is a good that is provided if and only if contributions reach some critical threshold. An archetypal example would be raising funds for, say, a new university music centre that costs £40 million. If, to a rough approximation, the £40 million is necessary and sufficient for the centre to be a success then the center is a threshold public good (Andreoni 1998). A slightly more mundane example would be a group of house mates trying to purchase, between them, a new television that will cost £200. This time the television is the threshold public good. More generally, the fixed costs associated with running any charity or group activity typically require a minimum (and often quite large) amount be reached to make the activity viable (Bagnoli and McKee 1991). This means threshold public goods are of wide practical interest.[1]

A large experimental and theoretical literature has considered whether threshold public goods can be provided efficiently. The theory primarily suggests they should (e.g. Bagnoli and Lipman 1989). In particular, it is a Nash equilibrium to provide a threshold public good, and so the trade-off between Pareto efficiency and individual rationality that we see for other types of public good does not exist. Experimental studies, however, provide a more depressing picture. The success rate at providing threshold public goods is far below 100 percent and more typically around 40 to 60 percent (Croson and Marks 2000).

This naturally raises the question of what factors increase efficiency, or the success rate of providing threshold public goods. One strand of the literature has looked at the consequences of different institutions, such as refunds, rebates, and sequential contributions (e.g. Coats, Gronberg and Grosskopf 2009). A second strand has looked at the consequences of differing strategic parameters, such as the threshold level and returns to the public good. It is this second strand of literature that we take as our starting point. The literature has highlighted two things that influence the success rate at providing the public good: the step return and net return (Cadsby et al. 2008). Informally, the step return measures the return on the public good relative to the threshold level, and the net return measures the absolute difference between return and threshold.

One thing notably absent from both of these measures is the endowment of potential contributors. Surely, however, the endowments will matter? Indeed, our intuition was that it

[1] Another example is political bargaining where success on, say, a climate change bill requires a critical threshold of voters or countries to contribute (McEvoy 2010).

should be easier to provide the public good if potential contributors are relatively well endowed. For instance, it would seem easier to raise the £40 million for the new music centre if there are some billionaire alumni to call upon. To the best of our knowledge, however, the prior literature has little to say on this question, with one exception. In a meta-analysis, Croson and Marks (2000) do consider the endowment relative to threshold level as a potential explanatory variable of success, and do find a positive effect, but also find the effect to be statistically insignificant.[2] Thus, whether the endowment really does matter remains an open and intriguing question.

The objectives of this paper are, hopefully, now clear: we shall ask whether the size of endowment does influence success at providing a threshold public good and, if so, why. We address this question in two stages. First, we briefly review the literature, much of which appears after the meta-analysis by Croson and Marks (2000), and revisit the evidence for whether the endowment matters. Such an exercise is informative but ultimately limited by the fact that no study has explicitly focused on the size of endowment. Our second, and main, task is, therefore, to report on experiments that we did in order to specifically question whether the endowment matters.

Our results suggest that our intuition, of larger endowments resulting in greater success at providing the public good, may need some revision. If the endowment is relatively large and so people only need give a little, or a few people alone can finance the good, then we do find, as expected, that the good is provided relatively more often. We also find, however, that if the endowment is relatively small and so all people need to give most of their endowment to finance the good then the good is also provided relatively more often. This points towards a U shaped relationship between the endowment and success, and we show how this can be explained by strategic incentives.

Before proceeding with the more detailed analysis we briefly want to emphasize that the relevance of the endowment is an important practical and policy question, as well as an intriguing theoretical one. It is socially efficient that threshold public goods be provided and so it is important to know what factors are likely to affect the success in providing such goods. This can inform a policy maker when intervention may be necessary or can inform the group when they may need to help themselves somehow in order to successfully provide the good. Our

[2] To clarify, Croson and Marks (2000) use threshold/endowment as the explanatory variable. We shall focus on endowment/threshold. Hence, they obtain a negative coefficient but we interpret this as suggestive of a positive effect.

results suggest that most help is needed when the threshold public good does require people to give a significant amount, and so there is the incentive to free-ride, but the contribution of no one person is too critical, and so the possibility to free ride exists. This is when the conflict of interest between contributors is at its highest.

We proceed as follows: in section 2 we define and explain a threshold public good, in section 3 we review the literature, in section 4 we explain our experimental design, in section 5 we provide our main results and in section 6 we conclude. Additional material is contained in an appendix.

2. Threshold public good game

In the threshold public good game considered here there are n players, each endowed with E units of a private good. Note that we shall only focus on a symmetric case. Independently and simultaneously the players must decide how much of their endowment to contribute to a group project. If total contributions exceed some threshold T then each player receives an additional V units of the private good and we say that the group was successful in providing the public good. So, V is interpreted as the value of the public good. If contributions are below the threshold each contribution is refunded and if contributions are above the threshold no money is rebated. So, if we denote the contribution of player j by c_j for all j the payoff of player i is

$$u_i(c_1, \dots, c_n) = \begin{cases} E - c_i + V & if \ \sum_{j=1}^{n} c_j \geq T \\ E & otherwise \end{cases}$$

This game has a large set of Nash equilibria that can be distinguished into two broad categories. First, there is a set of equilibria where the sum of contributions matches the threshold. Specifically, vector of contributions $(c_1, \dots, c_n)$ is a Nash equilibrium with public good provision if

$$\sum_{j=1}^{n} c_j = T \text{ and } c_i < V \text{ for all } i.$$

Note that no player would gain from contributing less, because the threshold is not met if they do so and $c_i < V$ so they gain from the public good. Also, no player gains by contributing more because they would lose the value of that extra contribution. All of the Nash equilibrium in this set yield the same total payoff to players but differ in how this total is distributed. A player who contributes relatively less receives a relatively bigger share of the total payoff.

There also exists a second set of equilibria where the sum of contributions is less than the threshold. Specifically, vector of contributions $(c_1, \ldots, c_n)$ is a Nash equilibrium with no public good provision if

$$\sum_{j=1}^{n} c_j < T \quad \text{and} \quad T - \sum_{j \neq i} c_j > min\{E, V\} \text{ for all } i.$$

In this case, no player strictly gains from contributing less because their payoff would remain E. Similarly no player would gain from contributing more because the amount they would have to contribute to reach the threshold is greater than either their endowment or the value of the good. For this set of Nash equilibrium the payoff of every player is E irrespective of their contribution.

Any Nash equilibrium with public good provision Pareto dominates a Nash equilibrium with no public good provision. But, the 'selfish' ideal for a player is for the threshold to be met while he or she contributes as little as possible. This creates an interesting coordination problem with conflict of interest in which players want to collectively contribute enough to meet the threshold while individually want to contribute as little as possible. One potential solution is for players to split things equally so that each player contributes T/n. This is a Nash equilibrium that gives every player the same payoff and so would seem a natural focal point. It is, however, only one of the many possible Nash equilibria with public good provision.

It should be apparent than the promise of a refund but no rebate creates a form of asymmetry whereby it cannot be a Nash equilibrium for total contributions to exceed the threshold but it can be a Nash equilibrium for contributions to be short of the threshold. There is no denying that the presence or not of refunds and rebates can make a difference (Marks and Croson 1998; Spencer et al. 2009). The difference is not, however, as stark as this asymmetry may suggest. This is because even with a refund or without a rebate there is an incentive for a player to contribute less in the hope that others will contribute more. The presence of not of a refund or rebate changes how risky this is to do, but not the incentive to do so. This is reflected in prior results that show a change in the variance of contributions when rebates and refunds are altered, but not much change in the success rate at providing the public good (e.g. Marks and Croson 1998). We shall comment more on the consequences of refunds and rebates in the conclusion.

3. The prior literature and some conjectures

Numerous studies have shown that the success rate at providing threshold public goods is far below 100 percent and depends on the fundamental parameters of the game. Cadsby et al. (2008) discuss two summary measures of the strategic trade-off players face (see also Cadsby and Maynes 1999 and Croson and Marks 2000). The step return is the ratio between the value of the good and the threshold:

$$SR = \frac{V}{T/n}.$$

The net return is the absolute difference between the value of the public good and the threshold:

$$NR = V - \frac{T}{n}$$

Intuitively the higher is the step return and net return then the relatively more a player values the public good and so the more she may be willing to contribute. This intuition suggests a positive relationship between the step and net return and the success rate of providing the public good. The results of Cadsby and Maynes (1999), Croson and Marks (2000) and Cadsby et al. (2008) do suggest that the higher the step return the higher the success rate at providing the public good. The step return does therefore have the effect we might expect. The effect of the net return is slightly more subtle. The higher the net return the worse the success rate seems to be in initial plays of the game but the better the success rate with experience. So, a high net return seems to make coordination more likely if players have time to learn.

One notable thing about both the step return and net return is the absence of the endowment. Indeed, there are four fundamental parameters in a threshold public good game, *E*, *T*, *V* and *n*, and *E* is the one that is absent from both these measures. This is not to say, in any way, that the step and net return are not good measures. It does, however, suggest that we might want to consider additional measures that do take into account the endowment. Following the logic of the step and net return we propose two measures. We define the endowment multiple as the ratio between endowment and threshold. Formally,

$$EM = \frac{E}{T/n}.$$

Note that the inverse of the endowment multiple is the proportion of the endowment players would have to give to provide the threshold public good. We define the endowment return as the endowment that will remain after meeting the threshold. Formally,

$$ER = E - \frac{T}{n}.$$

The parallels between the SR and NR and EM and ER are hopefully apparent and one of the main reasons we choose these measures rather than any other.

The primary hypothesis we wish to test in this paper is the following:

Hypothesis 1: Ceteris paribus changes in EM or ER significantly change the success rate of providing the public good.

This hypothesis is deliberately agnostic about the direction of the change or whether the ER will have different effects to the EM. This is primarily because there is no strong theoretical argument to guide us in the direction of change and so we prefer to be guided by the evidence.

One important source of evidence is the prior literature. In table 1 we summarize the results of experiments from six papers. The experiments are chosen to be directly comparable to the setting of interest here. In particular, there are refunds, no rebates, simultaneous contributions and repeated matching. The only exceptions are differences in the number of periods (25 or 14) and the second set of experiments by Croson and Marks (2001) where suggested contributions were made to players before they contributed.[3] To the best of our knowledge these are the only directly comparable experiments reported in the literature. Comparing across experiments we see a lot of variation in the four measures of strategic trade-offs. This variation is arguably too much to clearly see the influence of one measure, which motivates our experiments, but it can be a useful guide to the likely effects.

[INSERT TABLE 1 AROUND HERE]

Figures 1 and 2 pick out some of the data from table 1 by plotting the success rate against EM and ER, distinguishing by the number of players and number of observations. An eyeball

[3] Given that the suggestions had little effect we include these experiments here.

test of the figures suggests that the success rate may be increasing in both the EM and ER but that this is an easier argument to make for EM. Table 2 details the results of weighted least square regressions in which we regress the success rate against combinations of SR, NR, EM and ER, together with a dummy for whether n is five or ten. In specification (1) we use just SR and EM, in specification (2) we use NR and ER, in specification (3) we use all four measures, and in specification (4) we follow the strategy of Croson and Marks (2001) using SR and 1/EM.[4] The results strongly support the idea that EM does matter, both in a statistical and economic sense. The evidence on ER is more mixed (but it is for SR and NR as well).

[INSERT TABLE 2, AND FIGURES 1 AND 2 HERE]

We do not want to push the results of this analysis too far because it is not clear how readily one can compare across experiments. The results are, however, suggestive of a positive relationship between the level of endowment and success at providing the public good. This is consistent with basic intuition that the more players are endowed with the more willing they may be to contribute towards the good. This motivates our second hypothesis.

Hypothesis 2: A ceteris paribus increase in ER or EM increases the success rate of providing the public good.

Having made this hypothesis we next want to point out one important caveat. To motivate the point suppose that $E = T/n$ and so $ER = 0$ and $EM = 1$. In this case the threshold public good is provided if and only if every player contributes their full endowment. Given that players will be given a refund if the threshold is not met it is a weekly dominant strategy for a player to contribute her full endowment. If she contributes her full endowment and someone else does not, she gets her contribution back and so has lost nothing. If she contributes her full endowment and everyone else does as well then she benefits from the public good and would not have done so if she had contributed any less.[5] Intuitively, therefore, we should expect all players

[4] Given any three of SR, NR, EM and ER it is possible to work out the other. That is why we report regressions with only two at one time. The relationship between the measures is not, however, linear and so a regression with all four measures is valid.

[5] Note that the refund is crucial to making this argument. Without a refund the game becomes similar to that of a weak link game and the evidence of coordination in such games points towards no-coordination (Camerer 2003).

to contribute because there is no possible loss in doing so. Any equilibrium refinement would give this prediction.

This last observation provides something of a conundrum. We see that there are good theoretical arguments to expect a high success rate when ER is near 0 and EM near to 1. The results summarized in Tables 1 and 2 and figures 1 and 2 suggest, however, that we do not observe this, despite the ER and EM going to relatively low levels. In hypothesis 2 we have sided with the idea of a positive relation rather than be drawn too much by what happens if ER and EM are small. This can be justified by a 'discontinuity' in the success rate when the ER and EM and near 0 and 1, or reality diverging from the theoretical prediction (which is not so strange to say given that the theoretical prediction is a 100 percent success rate irrespective of the ER and EM). We are not, however, going to argue this case too much because it is an empirical question. What we are going to do is push hypothesis 2 hard by lowering EM below that observed in previous experiments.

4. Experimental design

To test hypotheses 1 and 2 we wanted to run experiments with ceteris paribus changes in ER and EM. Given the linear dependence of SR, NR, ER and EM it is difficult to vary one without varying the others. Indeed if we want to keep n constant and vary either T or V and ER or EM then we necessarily have to vary SR or NR. Ceteris paribus is, therefore, hard to apply in practice. To keep things tractable we fixed SR and considered five sets of parameters, where NR did vary. Table 3 summarizes the sets of parameters we considered.

[INSERT TABLE 3 AROUND HERE]

The baseline treatment is the same as the baseline treatment in Cadsby et al. (2008) and so provides a natural starting point. As table 3 shows, both the NR and SR are held constant in Low1 and High1, providing a ceteris paribus test of whether the EM and ER matter. We did not, however, want to restrict the analysis solely to one particular value of T and V. This motivates the Low2 and High2 treatments where we vary T and V keeping the ER constant. Doing this necessarily changes NR. This, however, also gives a chance to look at the consequences of a change in NR, comparing High1 to High2 and Low1 to Low2.

The experiments were run at the University of Kent with subjects recruited from the general student population. We ran six sessions in all. In each session subjects were randomly assigned to a group of 5, assigned to a treatment, and then played the relevant threshold public good game for 25 periods. Interaction within each group was anonymous and the groups remained the same throughout the 25 periods allowing us to look at dynamic group effects. [6] In total there were 4 groups for the baseline treatment and 5 groups for each of the other treatments giving a total of 120 subjects.

The experiments were computerized (using Z-tree, Zurich Toolbox for Ready-Made Experiments, see Fischbacher 2007). The language used in the instructions and experiment was deliberately neutral, for example, asking subjects how many tokens they wanted to allocate to a group account. [The instructions are available in the appendix.] At the end of each period subjects were told the total contribution to the public good, whether or not the public good had been provided, and their payoff. At the end of the session, each subject was paid in cash the total amount earned in the experiment. This was given by the total number of tokens accumulated over the 25 periods divided by 200, plus a £2 show-up fee. The average payment, including the show-up fee, was £10.70. Each experimental session lasted about 45 minutes.

5. Results

To give a first overall picture of the results, figures 3 to 7 plot the contributions over time for the five treatments and table 4 summarizes the success rate in providing the public good across the treatments. Looking first at the figures, the fluctuation of contributions around the threshold is what we have come to expect from the previous literature. The most noticeable difference between treatments is in the variance of contributions around the threshold; in the Low1 and High2 treatments there is very little variation around the threshold while in the baseline and High1 treatments there is notably more variation. We will look at this in more detail in section 5.2. The thing that stands out most in table 4 is the relatively low success rate in the baseline treatment. It is also noticeable that the success rate in High1 and Low1 is increasing over time while that in the baseline is decreasing. We will look at this in more detail now.

[6] The subjects were assigned to sessions and groups randomly, so the chance that two subjects who knew each other were in the same group, and knew that, was very low.

[INSERT FIGURES 3 TO 7 HERE AND TABLE 4]

5.1 Success rates

In order to get a better idea whether there were significant treatment effects in terms of the success rate at providing the public good we ran an OLS regression with the number of successes in a group as the dependent variable. Table 5 gives the results. In interpreting these results, recall that there were 25 periods, and so, for instance, a constant of 12.5 means the standard is a 50 percent success rate. Given that there are only four groups in the baseline treatment and five groups in the other treatments, statistical power is clearly weak. Even so, we find statistically significant higher success rates in the High2 and Low2 treatments across all periods, and in all four treatments in the last five periods, when compared to the baseline. No statistically significant differences are observed between the other four treatments. We obtain a very similar story when using a Mann-Whitney test.

[INSERT TABLE 5 HERE]

It does look, therefore, as if that the success rate in the baseline treatment is lower than in other treatments. This makes it especially important to assess whether the success rate we observed in the baseline is consistent with that observed in the previous literature (see table 1). Essentially it is. Our success rate of 50 percent compares to the 44, 59, 55 and 58 percent previously seen. Note that none of these success rates are better than we observed in all our other four treatments. That we obtain a decreasing success rate over time does contrast with Cadsby et al. (2008), who found an increasing success rate over time, but is more similar to what is observed in Croson and Marks (2000, 2001). It does seem, therefore, that the low success rate we observe in the baseline is no accident but a good reflection of what happens in this case.

This low success rate is not consistent with hypothesis 2 because the values of EM and ER were intermediate in this treatment. Instead, it suggests a U shaped relationship between success rate and EM and ER.[7] To explore that idea further we ran a random-effects logistic regression with the probability of success as the dependent variable and either EM and EM^2 or

[7] It is also noticeable that, while there were no statistically significant treatment effects other than compared to the baseline, the aggregate results are consistent with a U shape. In particular, going from low to high EM we get success rates of 71.2, 64.8, 50, 60 and 70.4 percent.

ER and ER^2 as explanatory variables.[8] The results, over all 25 periods, are presented in table 6. To put these results in some context figures 8 and 9 update figures 1 and 2 with our experimental results and the estimated line of fit using the results from columns (2) and (4) of table 6. The clear picture we get is of U shaped relationship.[9] In order to understand this relationship better it is useful to look in more detail at the variance in contributions.

[INSERT TABLE 6 AND FIGURES 8 AND 9]

5.2 Variance in contributions

Figures 3 to 7 gave the impression that the variance in group contributions differed over the five treatments. Table 7 shows some descriptive statistics on this variance. One interesting thing to note is how group contributions were relatively high in the baseline treatment despite the success rate being relatively low. This puzzle is explained by the relatively large variance of contributions in this treatment. It is also noticeable that there is a decline in the variance of contributions, captured by the absolute deviation of group contributions from the threshold level, in all treatments bar the baseline.

[INSERT TABLE 7 HERE]

Using a Mann-Whitney test to compare the sum of absolute deviations we do indeed find significant differences between the baseline and all other treatments, except High 1, but no differences between these other treatments.[10] Table 8 reports the results of running an OLS random-effects regression, similar to that considered for successful provision, but with absolute deviation as the dependent variable. We observe a clear and very strong relationship between absolute deviation and a quadratic formula of both the EM and ER.

[INSERT TABLE 8 HERE]

[8] The random-effects regression is to capture the fact that, since each group solves 25 choice problems, observations are not independent.

[9] A log-likelihood ratio test for joint significance of the EM regressions (1) and (2) and ER regressions (3) and (4) show that both the squared terms are important in explaining the probability of success (i.e. for the EM, LR=3.544<$\chi^2_{1,0.05}$=3.841, and for the ER, LR=3.508<$\chi^2_{1,0.05}$=3.841).

[10] The Low1, Low2 and High2 treatment are significantly different when compared across all periods (p value 0.016, 0.032 and 0.032 respectively) but the High1 is not (0.286).

To put the numbers in table 8 in some context: When the EM is equal to 2.2 (in the baseline treatment), the estimated absolute deviation (over all 25 periods) is 11.37. Increasing the EM to 5.5 (in the High2 treatment) reduces the absolute deviation to 5.02. Decreasing the EM to 1.1 (in the Low2 treatment) reduces the absolute deviation to 6.28. Similarly, when the ER is equal to 30 (in the baseline), the estimated deviation is 15.6. Increasing the ER to 45 (in the High1 and High2 treatments), decreases the absolute deviation to 8.64 and decreasing the ER to 5 (in the Low1 and Low2 treatments) decreases the absolute deviation to 6.2. It appears, therefore, that there is an inverted U shaped relationship in which the variance of contributions is smaller when the ER and EM are relatively small or large.

5.3 Individual data

It seems reasonable to conjecture that the U shape relationship we observe for success rate is related to the inverse U shape relationship we observe in terms of the variance in contributions. This is seemingly confirmed by looking at some individual level data, as figures 10 to 12 will help illustrate. These figures plot the distribution of individual contributions during the 25 periods in each of the treatments.

Figure 10 plots the distribution for the Low1 and Low 2 treatments. Recall that in the Low1 treatment subjects are endowed with 30 and need to contribute on average 25 while in the Low2 treatment they are endowed with 55 and need to contribute on average 50. The big spikes we find at 25 and 30 in the Low1 treatment and 50 and 55 in the Low2 treatment are consistent with a high success rate and low variance in contributions. Basically, subjects had little choice but to contribute all, or almost all, of their endowment and they were seemingly happy to do this. This fits with the idea discussed in section 3 of contributing being a weakly dominant strategy if the EM and ER are low.

Figure 11 plots the distribution of contributions for the High1 and High2 treatments. Recall that in the High1 treatment subjects were endowed with 70 and needed to contribute on average 25 while in the High2 treatment were endowed with 55 and needed to contribute on average 10. There is slightly more dispersion of contributions in these treatments but the big spikes at 10 in the high2 and at 25 and 30 in the high1 treatment are still consistent with a high success rate and low variance in contributions. This time it seems as though the amount subjects needed to contribute was relatively so little that most contributed enough. This is consistent with our initial intuition and hypothesis 2.

Finally, figure 12 plots the distribution of contributions for the baseline treatment. The difference between this treatment and the others could not be starker, as demonstrated by the scale on the y-axis. In this treatment subjects were endowed with 55 and need to contribute on average 25. We do see a spike in the data at 25 but there is clearly a lot of dispersion. We also see at spike at 0, and this is the only treatment where we do so.

[INSERT FIGURES 10-12 HERE]

Given what we have seen it seems reasonable to suggest that the dispersion in contributions in the baseline treatment is caused by: (i) the endowment being large enough that subjects can try to free-ride and contribute relatively little, which was not an option in the low treatments, and (ii) the endowment being small enough that the gain from free-riding is relatively large, which was not the case in the high treatments. This combination of a possibility to free ride and a significant gain from doing so seem to create too much conflict between group members for them to coordinate. Hence we see a large variance in contributions and little success in providing the public good. We have a plausible explanation for both the U shapes discussed above.

To back up this story a little, figure 13 plots the proportion of subjects choosing the modal contributions in each treatment. In the baseline treatment, there were 60 percent of subjects who chose a contribution of 25 in period 1, but that proportion soon declined. Contrast that with, say, the low1 treatment where there were relatively few who chose to contribute 30 in period 1 (where an average of 25 was needed) but that proportion soon rose. This fits the dynamic story of decreasing success with no fall in the variance of contributions in the baseline treatment while increasing success and a declining variance in the Low1 treatment. It also supports the explanation above that coordination was easier when the endowment was relatively low.

[INSERT FIGURE 13 HERE]

6. Conclusion

Many goods can be approximated as threshold public goods and so it is very important to know when such goods are likely to be produced at the efficient level, and when not. This question is made more pertinent by the consistent evidence that groups can be disappointingly bad at providing threshold public goods. The prior literature has highlighted strategic variables that seem to affect the success rate at providing such goods (e.g. Cadsby et al. 2008) but little attention has so far been given to the role of the endowment. The motivation behind this study was to see whether the endowment does matter.

Our prior intuition was that the larger the endowment, i.e. the more money people have relative to the average amount needed to fund the public good, the more likely the good would be provided. We found some evidence for this in the prior literature but not in the experiments we ran to directly test this hypothesis. Instead, we observed a U shaped relationship in which success at providing the public good is relatively high if the endowment is either small or large. This can be explained by strategic incentives: If the endowment is small then people have no alternative but to contribute if they want the public good provided. If the endowment is large then people gain little by trying to free ride. It is when the endowment is intermediate that a conflict of interest arises between group members, because there is the incentive and possibility to free ride. Given this conflict it can prove hard for the group to coordinate and provide the public good.

We feel this is a robust story that does show that the endowment matters. To put it in some perspective we can return to the music center example with which we began. If the University does have some billionaire alumni to call upon then there will probably be little problem funding the center. More interestingly, our results suggest that if it is known the music center can only be provided if everyone gives relatively a lot, then it will also be provided. That is because people who want the center would know that they are critical to it being provided so do need to contribute. The difficult middle ground is where people are being asked to contribute relatively a lot but know that if they do not give someone else could fill that gap. Charities seem keenly aware of this by trying to give the impression that every donation is critical.

One interesting issue raised by our results is that of refunds. It may be that the possibility of a refund is critical when the endowment is small because this makes it a dominant strategy to contribute. Intuitively, there is much less reason why a refund should matter when the endowment is larger. This suggests that there could be interesting interaction effects between institutions, like refunds, and strategic variables, like the endowment. It also suggests that the possibility of refunds should be considered a priority if endowments are relatively small. This is an issue that can be explored in future work.

Appendix

Here are the instructions for the baseline treatment. The instructions for all other treatments were identical except for the obvious change in parameter values.

In this experiment you will make decisions, and earn an amount of money that depends on what you and others choose. The money will be given to you at the end of the experiment in an envelope. Only you will know how much money you earned.

You have been organised into groups of 5. Each group will consist of the same 5 people for the duration of the session. The session will last for 25 periods. In each period you will be required to make a decision, and your total earnings will depend on your decisions in all periods.

At the beginning of every period you, and all other members of your group, will receive 55 tokens. Each of you must decide on your own how many of the 55 tokens to allocate to a group account.

If the total number of tokens allocated to the group account is 125 or more then you will each receive an additional 50 tokens.

If the total number of tokens allocated to the group account is less than 125 then you will receive no additional tokens but will get back any tokens you allocated to the group account.

So, at the end of the period:

If the total number of tokens allocated to the group account $\geq$ 125 your earnings = initial 55 tokens – tokens allocated to group account + additional 50 tokens

If the total number of tokens allocated to the group account < 125

your earnings = initial 55 tokens.

At the end of the session, you will be asked to fill in a short questionnaire. You will be paid in cash the total amount that you earned for all periods in the session plus £2. Each token will be worth 0.5p.

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Table 1: Prior results in the literature.

Paper	n	E	T	V	period	SR	NR	EM	ER	success rate %	groups
Cadsby et al. (2008)	5	55	65	26	25	2	13	4.23	42	54	4
	5	55	125	50	25	2	25	2.2	30	44	4
	5	55	65	38	25	2.92	25	4.23	42	79	4
	5	55	220	69	25	1.56	25	1.25	11	30	4
	5	55	220	88	25	2	44	1.25	11	54	4
Croson and Marks (2000)	5	55	125	30	25	1.2	5	2.2	30	33	4
	5	55	125	50	25	2	25	2.2	30	59	4
	5	55	125	75	25	3	50	2.2	30	63	4
Cadsby and Maynes (1999)	10	10	25	20	25	8	17.5	4	7.5	48	1
	10	10	25	20	14	8	17.5	4	7.5	71	1
	10	10	25	5	25	2	2.5	4	7.5	16	1
	10	10	50	7.5	25	1.5	2.5	2	5	28	1
	10	10	50	11	25	2.2	6	2	5	20	1
	10	10	50	20	25	4	15	2	5	44	1
	10	10	50	30	25	6	25	2	5	60	1
	10	10	75	10	25	1.33	2.5	1.33	2.5	10	2
	10	10	75	22.5	25	3	15	1.33	2.5	40	1
	10	10	75	32.5	25	4.33	25	1.33	2.5	36	1
Marks and Croson (1998)	5	55	125	50	25	2	25	2.2	30	63	4
Bagnoli and McKee (1991)	5	11	12.5	5	14	2	2.5	4.4	8.5	86	1
	10	11	25	5	14	2	2.5	4.4	8.5	64	1
Croson and Marks (2001)	5	55	125	50	25	2	25	2.2	30	55	5
	5	55	125	50	25	2	25	2.2	30	58	5

Table 2: The results of weighted least square regressions with success rate as the dependent variable and SR, NR, EM and/or ER as explanatory variables. We report the coefficient (standard error, probability).

	(1)	(2)	(3)	(4)
SR	6.57 (2.2, 0.007)	-	2.93 (2.73, 0.298)	6.59 (2.2, 0.008)
NR	-	0.57 (0.27, 0.051)	0.58 (0.28, 0.057)	-
EM	6.08 (2.5, 0.025)	-	9.89 (3.59, 0.013)	-
ER	-	0.80 (0.35, 0.036)	-0.03 (0.35, 0.937)	-
1/ER	-	-	-	-33.59 (14.2,0.028)
Constant	26.29 (6.9)	17.54 (14.0)	10.61 (11.46)	56.89 (9.59)
$n = 10$	-28.06 (6.9)	9.34 (12.4)	-14.8 (12.41)	-26.89 (7.0)

Table 3: The experimental parameters.

Treatment	n	E	T	V	NR	SR	EM	ER
Baseline	5	55	125	50	25	2	2.2	30
Low1	5	30	125	50	25	2	1.2	5
High1	5	70	125	50	25	2	2.8	45
Low2	5	55	250	100	50	2	1.1	5
High2	5	55	50	20	10	2	5.5	45

Table 4: A summary of the results. Success rates over the 25 periods.

				Success rate for provision % (periods)					
Treatment	NR	ER	EM	1-5	6-10	11-15	16-20	21-25	ALL
Baseline	25	30	2.2	60	60	50	45	35	50
Low1	25	5	1.2	44	56	84	68	72	64.8
High1	25	45	2.8	44	48	64	72	72	60
Low2	50	5	1.1	68	64	84	64	76	71.2
High2	10	45	5.5	80	64	68	68	72	70.4

Table 5: Results from an OLS regression with number of successes in the group as the dependent variable. The baseline is used as comparator. Given are the coefficient (standard error, p-value).

	All rounds	Periods 1-5	Periods 21-25
Low1	3.7 (2.709, 0.188)	-0.8 (0.797, 0.328)	1.85(0.912, 0.057)
High1	2.5 (2.709, 0.368)	-0.8 (0.797, 0.328)	1.85(0.912, 0.057)
Low2	5.3 (2.709, 0.065)	0.4 (0.797, 0.621)	2.05(0.912, 0.037)
High2	5.1 (2.709, 0.075)	1 (0.797, 0.225)	1.85(0.912, 0.057)
Constant	12.5(2.019, 0.000)	3 (0.594, 0.000)	1.75(0.912, 0.019)
R^2	0.212	0.312	0.258
Adj- R^2	0.046	0.167	0.1
No. of obs	24	24	24

Table 6: Results of a random effects logistic regression of probability of success (all periods). Given are coefficient (standard error, p-value).

	(1)	(2)	(3)	(4)
EM	0.037 (0.093, 0.69)	-0.882 (0.480, 0.066)	-	-
EM^2	-	0.138 (0.071, 0.051)	-	-
ER	-	-	-0.005 (0.008, 0.559)	-0.100 (0.050, 0.045)
ER^2	-	-	-	0.002 (0.001, 0.053)
Period	0.024 (0.012, 0.051)	0.024 (0.012, 0.051)	0.024 (0.012, 0.051)	0.024 (0.012, 0.051)
Constant	0.205 (0.324, 0.528)	1.286 (0.635, 0.043)	0.425 (0.305, 0.163)	0.940 (0.394, 0.017)
Log-likelihood	-380.665	-378.893	-380.576	-378.822
No. of obs	600	600	600	600

Table 7: Summary statistics on the variance in contributions.

Treatment	Mean	Std. Dev.	Absolute deviation from the threshold (periods)					
			1-5	6-10	11-15	16-20	21-25	All
Baseline	124.68	10.84	18.2	11.1	20.35	11.3	14.95	15.18
Low1	124.12	2.57	15.4	5.24	3.96	3.92	3.72	6.45
High1	124.19	6.56	17.48	12.04	10.48	6.56	4.44	10.2
Low2	248.33	3.29	9.36	8.52	2.84	6.84	3.44	6.04
High2	52.58	2.59	9.32	4.96	3.68	3.44	3.16	4.91

Table 8: Results of a random effects OLS regression of absolute deviation from the threshold (all periods). Given are coefficient (standard error, p-value).

	(1)	(2)	(3)	(4)
EM	-0.283 (0.626, 0.651)	9.477 (3.029, 0.002)	-	-
EM^2	-	-1.476 (0.448, 0.001)	-	-
ER	-	-	0.056 (0.056, 0.321)	1.111 (0.31, 0.000)
ER^2	-	-	_	-0.021 (0.006, 0.001)
Period	-0.402 (0.053, 0.000)	-0.402 (0.053, 0.000)	-0.403 (0.053, 0.000)	-0.403 (0.053, 0.000)
Constant	14.267 (2.045, 0.000)	2.849 (3.928, 0.468)	12.106 (1.923, 0.000)	6.411 (2.331, 0.006)
Prob > χ^2	0.000	0.000	0.000	0.000
No. of obs	600	600	600	600

Figure 1: The endowment return against success rate in the prior literature.

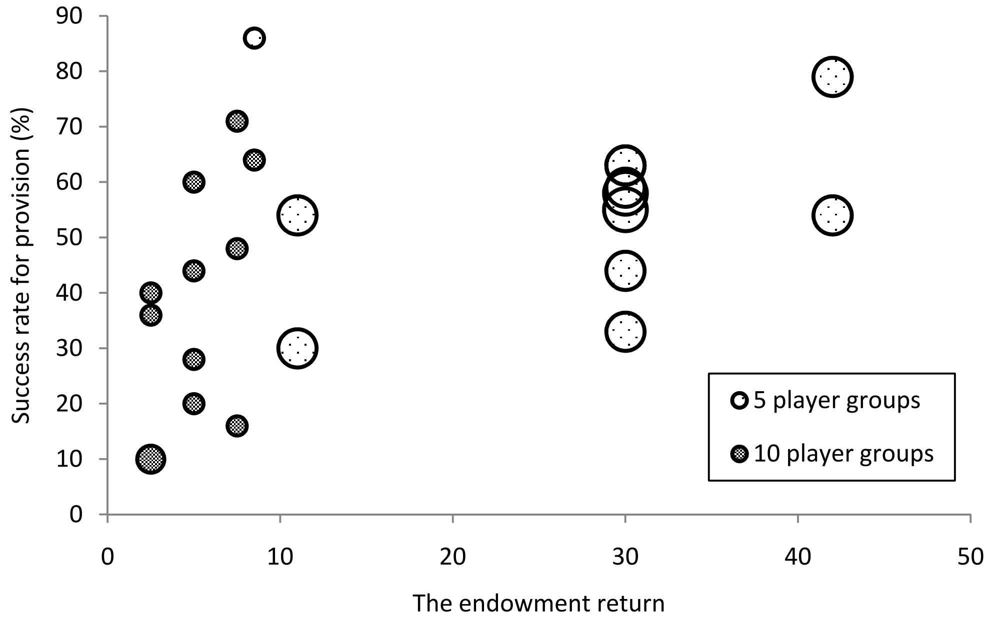


Figure 2: The endowment multiple against success rate in the prior literature,

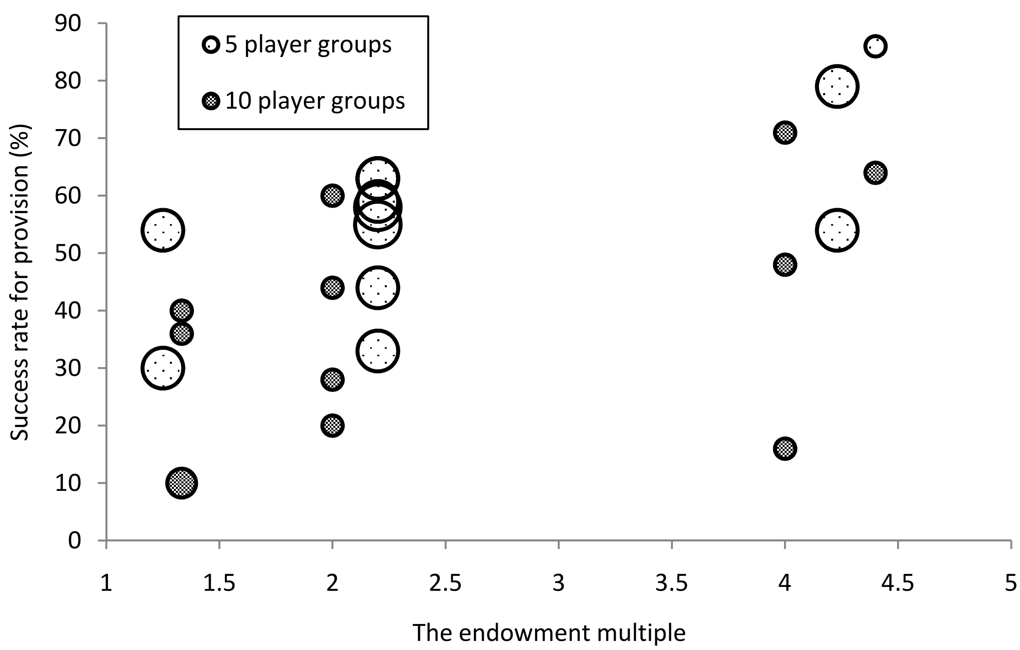


Figure 3: Group contributions in the baseline treatment.

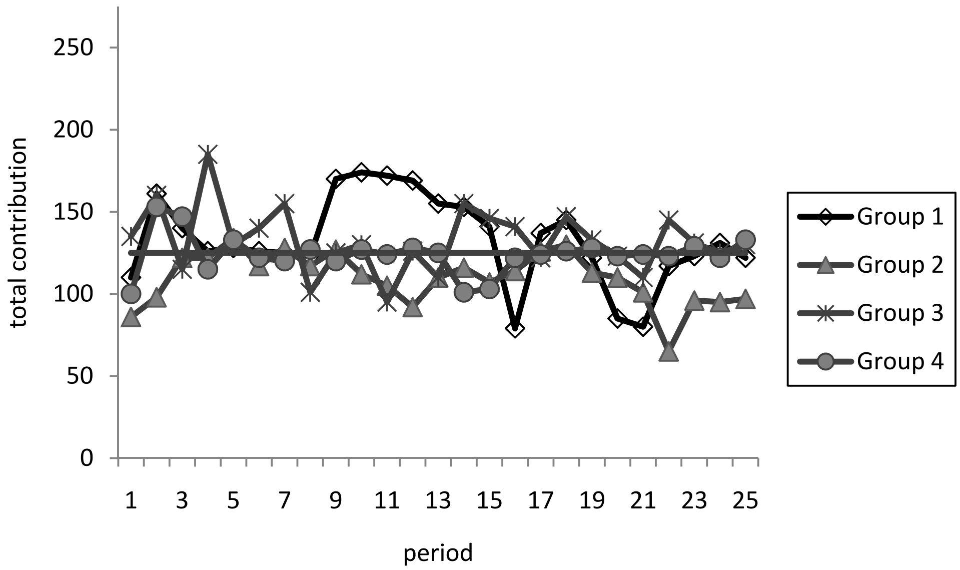


Figure 4: Group contributions in the Low1 treatment.

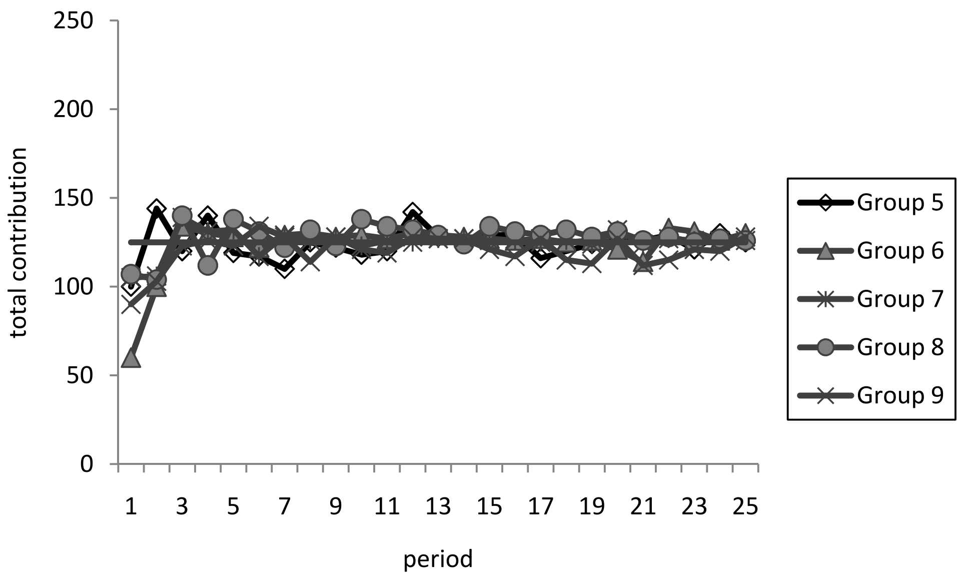


Figure 5: Group contributions in the High1 treatment.

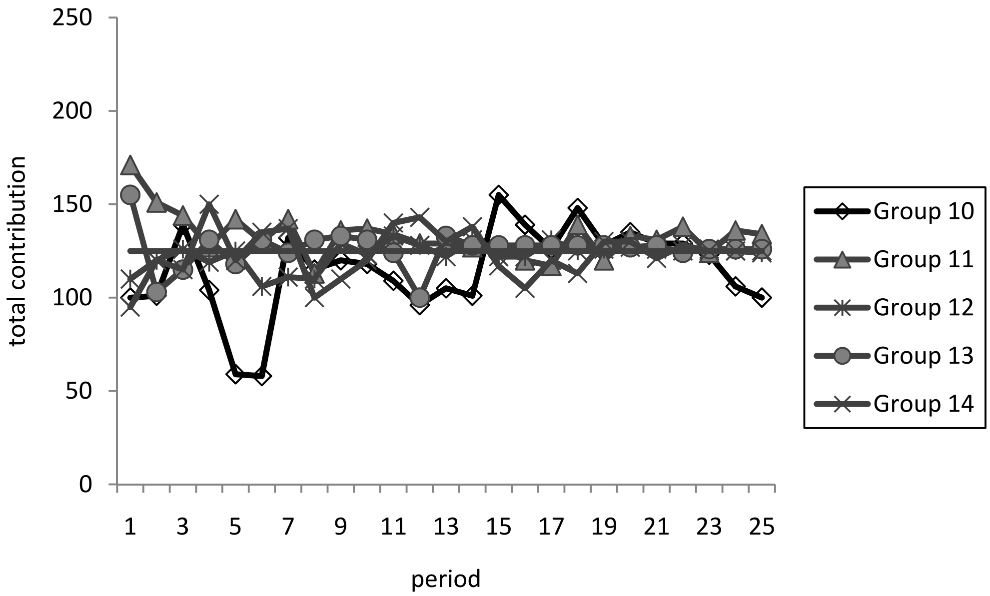


Figure 6: Group contributions in the Low2 treatment.

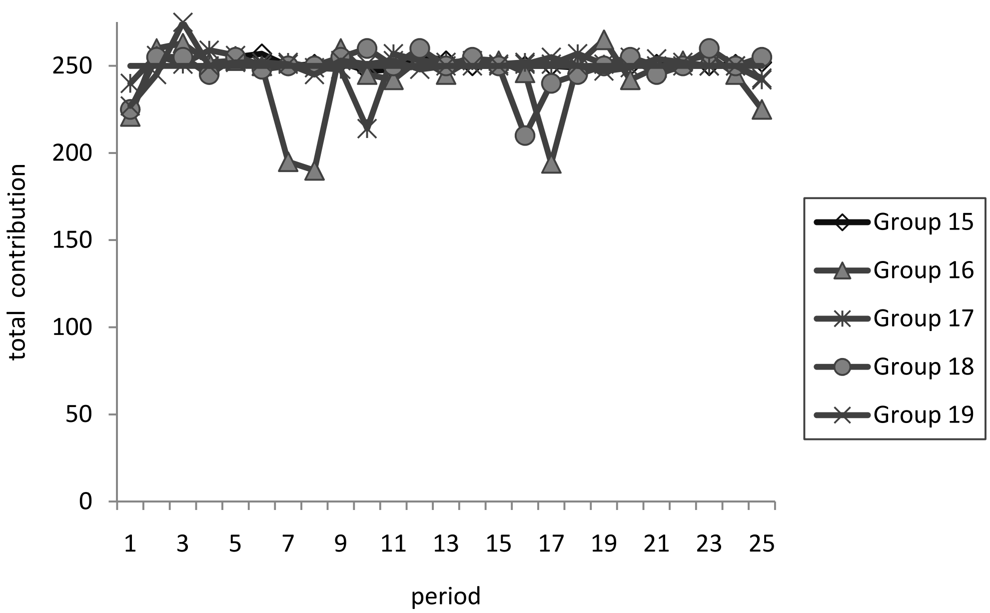


Figure 7: Group contributions in the High2 treatment.

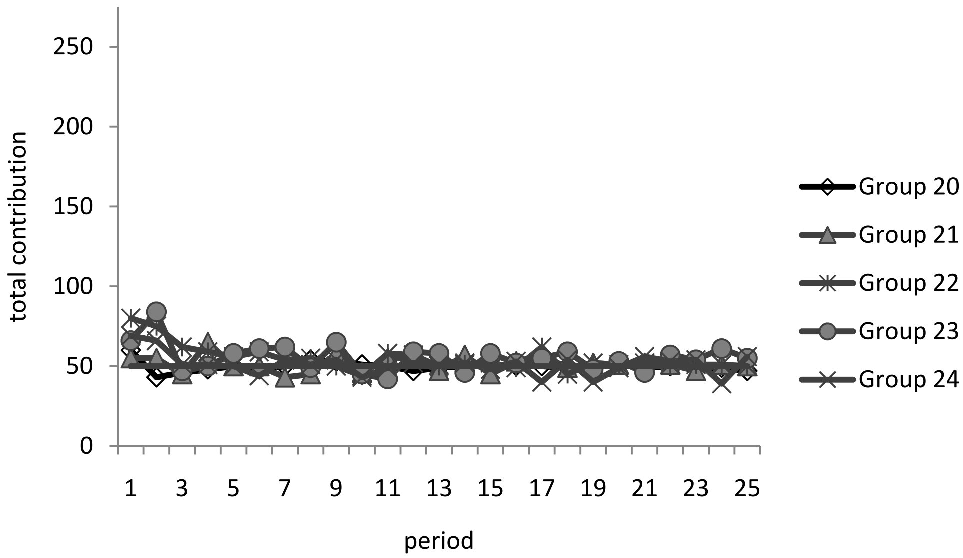


Figure 8: The endowment multiple and success rate in the prior literature, the new groups from our experiment, and an estimated line of fit (in period 20).

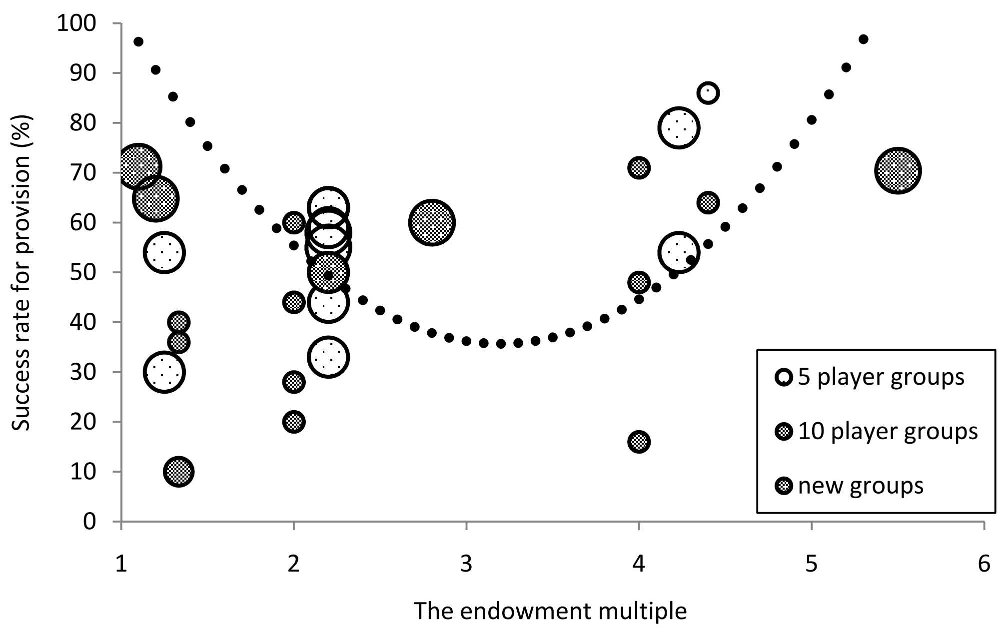


Figure 9: The endowment return and success rate in the prior literature, the new groups from our experiment, and an estimated line of fit (in period 20).

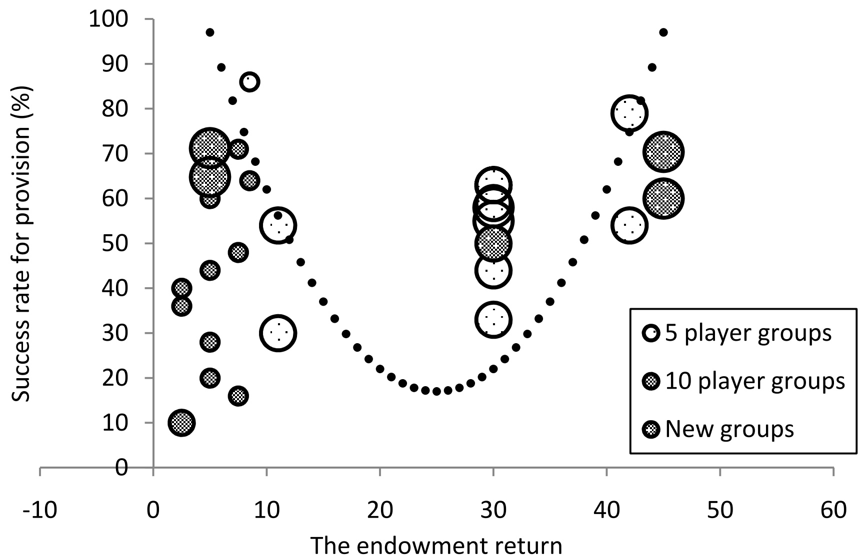


Figure 10: The histogram of contributions (all periods) in the Low1 and Low2 treatments.

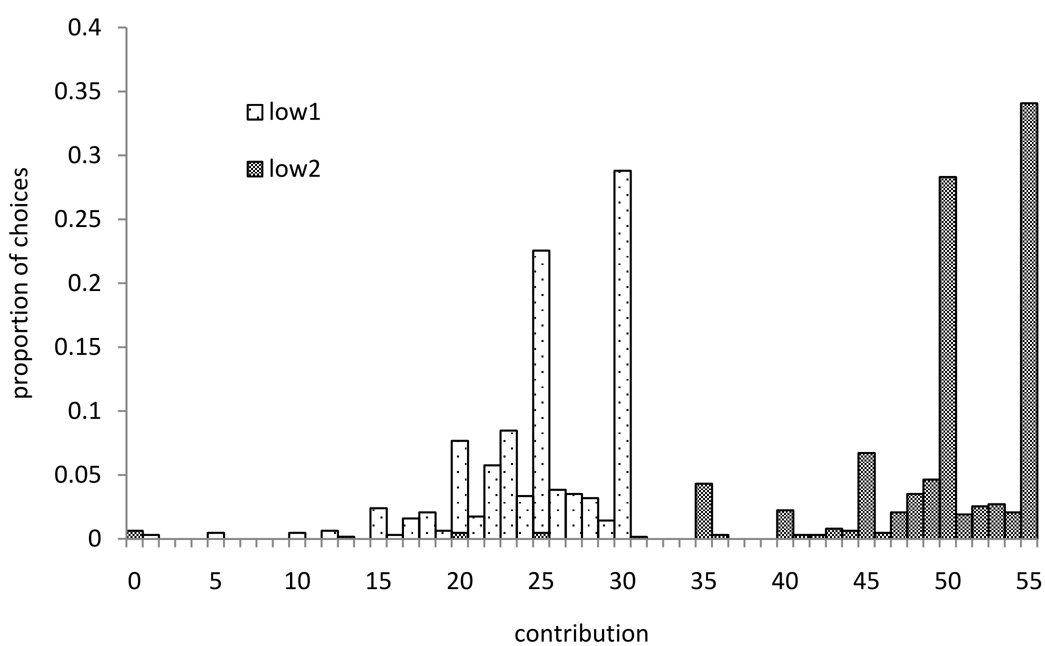


Figure 11: The histogram of contributions (all periods) in the High1 and High2 treatments.

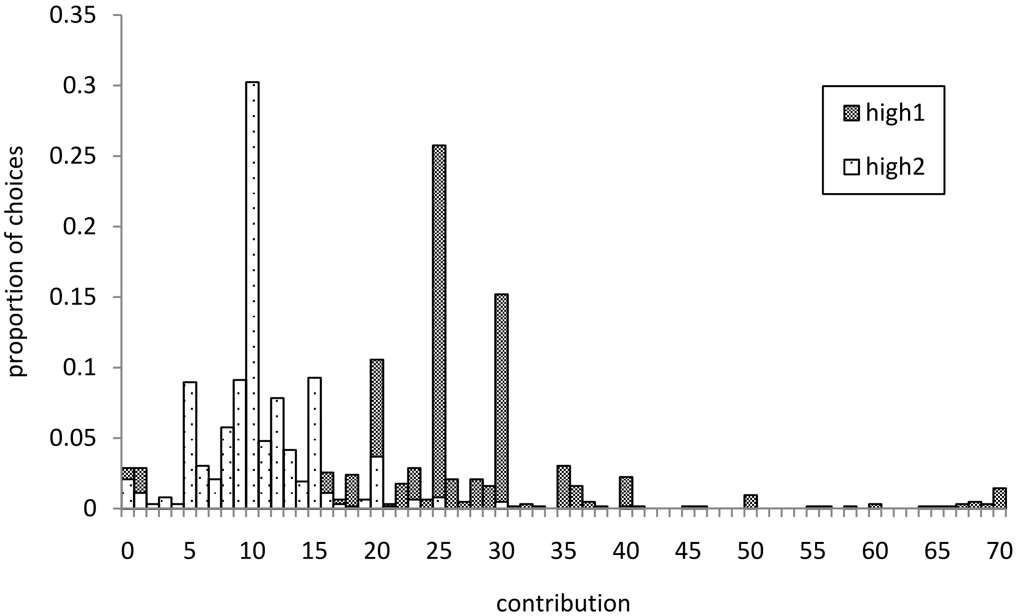


Figure 12: The histogram of contributions (all periods) in the baseline treatment.

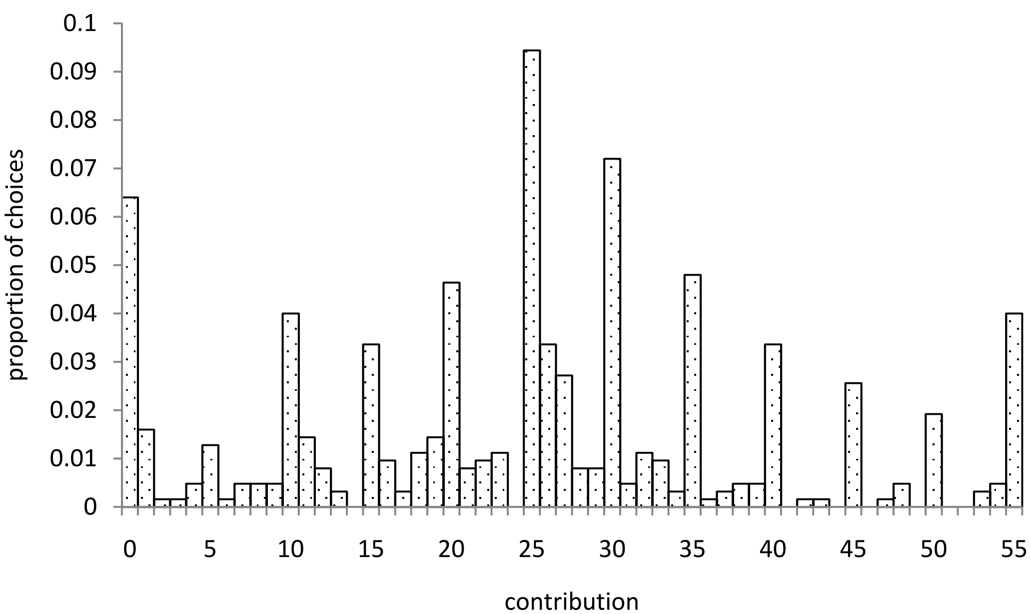
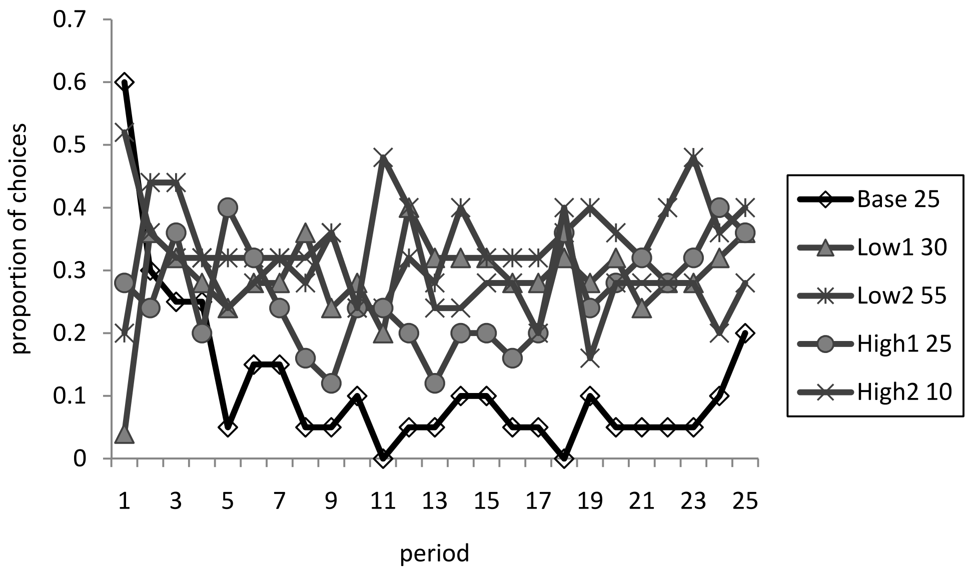


Figure 13: The proportion of subjects by round choosing the modal contribution in each treatment.



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