

# Simultaneous versus Sequential Public Good Provision and the Role of Refunds

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## An Experimental Study\*

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### Abstract

We experimentally study contributing behavior to a threshold public good under simultaneous and sequential voluntary contribution mechanisms and investigate how refund policies interact with the institution by either allowing for full refund in case the group's contribution does not meet the target level or not. We find that, for a given refund rule, efficiency is greater under a sequential contribution institution than under a simultaneous contribution institution. Furthermore, for a given order of contributions, full refund achieves higher efficiency by reducing the variance in individual contributions.

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# 1 Introduction

Conventional economic wisdom holds that the private provision of public goods leads to an inefficient allocation of resources. For the class of public goods models with variable individual contributions and a variable quantity of public good the inefficiency of the predicted and realized outcomes seems firmly established. Formal models of the voluntary contribution public goods game predict (e.g. Bergstrom, Blume, and Varian, 1986) and experimental studies provide strong support for the suboptimality hypothesis generated by the theoretical models (see Ledyard, 1995 for a survey of the laboratory research).

For the case of threshold public goods, however, theoretical and experimental studies suggest that private provision can lead to efficient outcomes.<sup>1</sup> Bagnoli and Lipman (1989) show theoretically that, in a game of simultaneous voluntary contributions to a threshold public good, individuals have sufficient incentives to achieve a Pareto efficient equilibrium allocation when a full refund is offered if contributions do not meet the threshold level. However, experimental papers which test this theoretical prediction provide conflicting evidence. Bagnoli and McKee (1991) find strong support, while Isaac, Schmidtz and Walker (1989) and Mysker, Olson, and Williams (1996) find only weak support for the hypothesis of successful public good provision via simultaneous contributions with full refund.<sup>2</sup>

The above mentioned literature on voluntary contributions assumes that contributions are made simultaneously. However, the characteristics of many fundraisers suggest a sequential order in which contributions are made. For example, fundraisers in practice often use a sequential solicitation strategy and announce contributions given during the fund drive (e.g. a fundraising thermometer outside a construction site or public radio fundraising campaigns). While some theoretical work (e.g. Varian, 1994) predicts an inefficient allocation of resources even for a contributions mechanism that uses

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<sup>1</sup>A threshold public good can only be provided if a given threshold of contributions is met. Such public goods are also referred to as discrete or fixed quantity public goods and have been justified as being an appropriate description of the lumpy nature of many public goods (i.e. parks, roads, bridges, community libraries etc.).

<sup>2</sup>Observed frequencies of the successful provision of the threshold public good in those three papers are: Bagnoli and McKee (1991) – 85.7%, Isaac, Schmidtz and Walker (1989) – 43% to 57% depending on the threshold and Mysker, Olson and Williams (1996) – 60%.

sequential contributions, experimental studies have shown that a sequential mechanism can improve public good provision relative to a simultaneous mechanism. Potters, Sefton and Vesterlund (2005) examine contributions to a linear public good when some donors are better informed than others about the quality of the public good, and the sequence of contributions is endogenously determined by the donors. They find that donors predominantly choose to contribute sequentially, and that the resulting contributions are larger than those of the simultaneous-move game. Although the gain from sequential moves is smaller when the sequence is set exogenously. Erev and Rapoport (1990) find evidence in favor of the sequential contribution mechanism in the case of a threshold public good when no refund is offered and individual contributions are either all or nothing (see also Rapoport and Erev, 1994).<sup>3</sup>

Our paper aims at exploring the effects refund policies and order of contributions have on individual contributions to a threshold public good. We are, in particular, interested in the relative role these two features (refund and order) play. Which one is more important and how can an efficient provision of a threshold public good be guaranteed?

Our experimental implementation therefore compares contributing behavior in a simultaneous mechanism with and without a full refund to that of a sequential mechanism with and without a full refund. We find that for a given refund rule, the sequential contribution mechanism unambiguously provides the public good more often and more efficiently. Arguably, the sequential contribution mechanism with exogenously fixed ordering might be a little difficult to implement. More commonly, we observe sequential public good games where the order comes about endogenously. If the implementation of a sequential voluntary contribution mechanism is not possible, then the introduction of a full refund rule can be used to efficiently provide the threshold public good. We find that a simultaneous contribution mechanism with full refund provides the public good just as efficiently as a sequential one without refund. Offering a full refund if a specific threshold is not met could arguably be instituted through assurance that mailed in cheques will

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<sup>3</sup>In a theoretical paper, Vesterlund (2003) introduces imperfect information about the quality of the public good and finds that an announcement strategy of sequential contributions is optimal and leads to higher contributions compared to those that would result if the quality of the charity had been common knowledge.

be destroyed or credit cards will not be charged unless the specified threshold is met. Clearly, if there are no constraints, on either the order or the refund rule, our results suggest that the sequential contribution mechanism with full refund is the best.

The paper is structured as follows, section 2 will introduce our experimental design and the choice of parameters. Section 3 summarizes the theoretical predictions. Section 4 discusses the experimental results and section 5 concludes. Appendix A illustrates the experimental interface and Appendix B contains details of our random effects Tobit estimations.

## 2 Experimental Design

We study a simple, common, provision point public goods game. Individuals are given an endowment  $w_i$  of a private good  $x$ . They can make contributions  $c_i$  of their endowment towards the provision of a fixed quantity of the public good  $g$ . The public good is provided if and only if the sum of the contributions from all players is greater than or equal to the cost of the public good  $P_g$ . The cost of the fixed-size public project thus defines the provision point for the game. The payoff structure is of the linear symmetric threshold form (see Ledyard, 1995). The payoff of group member  $i$  (of group size  $n$ ) is given by

$$\begin{aligned}
 v_i &= w_i - c_i + g \quad \text{if } \sum_{j=1}^n c_j \geq P_g \\
 &= w_i - \theta c_i \quad \text{otherwise,}
 \end{aligned}$$

where  $\theta$  is a parameter that captures the refund policy if the public good is not provided because of insufficient contributions of the group members.  $\theta$  is equal to 0 under the full refund rule and equal to 1 under the no refund rule. Note that excess contributions are not rebated.<sup>4</sup> In all of our

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<sup>4</sup>The impact of alternative rebate rules within a threshold public goods environment is studied by Marks and Croson (1998). Offering full refund differs from offering rebates. While rebate rules specify how excess contributions over the threshold amount are distributed, refund rules specify what happens to contributions in case the threshold is not met.

experiments, we set  $w_i = 5$  tokens,  $g = 6$  tokens,  $P_g = 12$  and  $n = 4$ . We employed a  $2 \times 2$  between-subject design, in which we varied whether participants simultaneously or sequentially pledged their contributions as well as whether a refund was offered or not. Table I summarizes the details.

TABLE I:  
THE 2×2 EXPERIMENTAL DESIGN

		<i>Order of Contributions</i>	
		Simultaneous	Sequential
<i>Refund</i>	Full Refund	3 cohorts	6 cohorts
<i>Policy</i>	No Refund	3 cohorts	3 cohorts

In the simultaneous contribution institution, agents simultaneously pledge contributions to the public good. In the sequential contribution institution, participants move in a randomly assigned sequence and each participant is informed about the amount that each previous participant has contributed. After each round, participants in both institutions were informed about the individual contributions of their group members.

Other design decisions involved isolating the effects of the order and refund rule from other possible treatment effects. First, we use the same presentation for the simultaneous as well as the sequential contributions mechanism, so that the only differences in presentation reflect strategic differences in the games (for the computer interface see Appendix A). Comparison of the two mechanisms should be based on strategic differences and not on potential differences in subjects' behavior due to alternative presentations.

We randomly reassign groups every period in an attempt to minimize repeated game effects and thus to approximate the theoretical environment of a one-shot game. When subjects are randomly rematched each period (and know and believe this) it is much harder for group effects to develop. Subjects have little incentive to try to signal to other participants and punishment of other participants is made impossible. The random matching protocol also reduces potential fairness concerns. In the sequential contributions mechanism, the subgame perfect equilibrium always favors the first two movers. Subjects may consider this unfair and try to come up with allocations which are more fair than the subgame perfect equilibrium. However, subjects are randomly rematched and randomly re-ordered each period so they have an equal chance every period of being assigned any order in the sequence. Therefore, everyone has a fair chance of being assigned to be the designated first mover and subjects should not regard the subgame perfect equilibrium as unfair.

Finally, given concerns for framing or presentation effects, we implemented the design in an abstract form while still capturing the essential theoretical elements of an experimental public goods environment. The presentation expresses the games in neutral terms, without explicit reference to the public goods nature of the environment. Terms such as ‘group account,’ ‘cooperation,’ ‘contribution,’ and ‘public good’ are not used.

In each experimental session we had 12 subjects participate in 20 rounds of a repeated one-shot game.<sup>5</sup> In each round, the 12 subjects were randomly regrouped into groups of 4. The experiments were conducted at the Economic Research Laboratory at Texas A&M. Participants were undergraduate students at Texas A&M recruited from introductory economics or business classes. Payoffs were accumulated over all 20 rounds. Each experimental token was worth \$0.0625. On average, participants earned \$7.61.<sup>6</sup> The main screen of the computer interface recorded a balance in cash earnings at all times so that subjects remained aware of the connection between their choices and their cash earnings.

## 3 Theoretical Predictions and Hypotheses

### 3.1 Simultaneous Contributions

The simultaneous games have multiple pure strategy Nash equilibria, some of which are efficient and some of which are inefficient. The only inefficient equilibrium in the no refund case is a contribution vector of (0,0,0,0). Allowing for full refund introduces a plethora of inefficient equilibria.<sup>7</sup> Left with a multiplicity of equilibria we turn to some refinements to help formulate our hypotheses.

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<sup>5</sup>The experimental sessions continued for another 20 rounds with a different provision point. For results on these see the working paper version of Coats and Gronberg (2001). Experimental results as well as average earnings reported here are for the first 20 rounds only.

<sup>6</sup>If the threshold public good was efficiently provided in each round, participants would have earned \$10. No show-up fee was paid. However, extra participants were paid \$5 if more than 12 participants showed up for any one session. The earnings might seem low from today’s perspective, however, the experiments were conducted in 1996.

<sup>7</sup>Any contribution vector that does not sum up to 12, in which the sum of contributions would remain less than 12 if any single player chooses to contribute her entire endowment of 5 (e.g. (2,2,2,2) and (0,1,2,3)) constitutes an inefficient equilibrium.

Given that it is common knowledge that everyone has the same endowment it seems reasonable to expect equilibria to be symmetric with respect to the contributions of the individual group members. Symmetric equilibria are behaviorally supported by the assumption that participants are concerned with fairness (e.g. Bolton and Ockenfels, 2000 and Fehr and Schmidt, 1999) since all participants would be contributing the same amount. The only two symmetric equilibria of the simultaneous games are  $(0,0,0,0)$  and  $(3,3,3,3)$ . These are equilibria under both refund rules and symmetry alone does not differentiate between these treatments.

However, as emphasized by Isaac, Schmidtz and Walker (1989) for a similar environment, for the efficient equilibrium to occur, individual group members might need a credible guarantee that others contribute as well. Such assurance is not needed in the case of a full refund. This means that even risk averse participants should feel safe contributing when a full refund is offered which is not necessarily the case without refund. Given this tension between the symmetric (and inefficient) and the symmetric (and efficient) equilibrium in the presence of risk aversion, we predict lower contributions and hence lower efficiency in the no refund case compared to the full refund case.

***Hypothesis 1:*** *Efficiency in the simultaneous institution with refund is higher than in the simultaneous institution without refund.*

## 3.2 Sequential Contributions

For the sequential games there exists a unique subgame perfect equilibrium prediction regardless of the refund rule, and that is given by the contribution vector  $(0,2,5,5)$ . In the event that earlier movers do not make subgame perfect choices, later movers still have an iterated dominant strategy to make the minimum contribution for which the remaining participants are capable of providing the necessary amount to provide the public good.

***Hypothesis 2:*** *Efficiency in the sequential institution is the same under either refund rule.*

Table II summarizes the theoretical predictions for all treatments. The theoretical predictions (and their refinements) suggest that under a full refund policy both the simultaneous as well as the sequential institutions will yield efficient outcomes. This prediction is weakened in the no refund case, since risk aversion might lead participants to prefer equal contributions of zero. However, given the multiplicity of equilibria in the simultaneous institution and the existence of a unique subgame perfect prediction for the sequential institution, we predict greater overall efficiency for the sequential institution.

**Hypothesis 3:** *Efficiency in the sequential institution is greater than efficiency in the simultaneous institution.*

TABLE II:  
SUMMARY OF THE THEORETICAL PREDICTIONS  
(predicted contribution vectors  $(c_1, c_2, c_3, c_4)$ )

		<i>Order of Contributions</i>	
		Simultaneous	Sequential
<i>Refund</i>	Full	any $(c_1, c_2, c_3, c_4)$ with $\sum c_i = 12$	$(0, 2, 5, 5)$
	Refund	focal $(3, 3, 3, 3)$	
<i>Policy</i>	No	any $(c_1, c_2, c_3, c_4)$ with $\sum c_i = 12$	$(0, 2, 5, 5)$
	Refund	focal $(0, 0, 0, 0)$ or $(3, 3, 3, 3)$	

## 4 Experimental Results

### 4.1 Aggregate Performance Measures

#### 4.1.1 Efficiency

Efficiency is measured as the percent of the feasible surplus for public good provision ( $n \cdot g - P_g = 4 \cdot 6 - 12 = 12$ ). Public good provision can be less than one hundred percent efficient for either of two reasons. First, contributions may fail to reach the provision point and, second, contributions may exceed the provision point. If contributions fail to reach the provision point, then efficiency is zero percent under the zero contribution outcome and under any other vector of insufficient contributions with a money-back guarantee; but without a full refund such outcomes (other than zero contribution) will result

in negative efficiency since part of the original endowment will be lost. If contributions exceed the provision point, the level of efficiency depends on the number of wasted tokens. For example, if all group members contribute all of their tokens then eight tokens are wasted and the outcome is thirty-three percent efficient. That is, efficiency ( $E$ ) is measured as:

$$E = \begin{cases} (24 - \sum_{i=1}^4 c_i)/(24 - P_g) & \text{if } \sum_{i=1}^4 c_i \geq P_g, \\ 0 & \text{if } \sum_{i=1}^4 c_i < P_g \text{ with full refund,} \\ (0 - \sum_{i=1}^4 c_i)/(24 - P_g) & \text{if } \sum_{i=1}^4 c_i < P_g \text{ with no refund.} \end{cases}$$

For both institutions we report on realized percent efficiency given the actual groupings of subjects that take place during the experiment. In the sequential institution this seems the natural choice. Subjects make their choices sequentially in each period and the realized outcomes depend entirely upon the choices specific to the actual groups. One could argue that for the simultaneous institution this is not necessarily the case, since we can think of four hundred and ninety-five equally likely groupings of the twelve observed choices each period.<sup>8</sup> However, since subjects get information about all individual contributions in their group at the end of each round, we decided to stick with the observed (i.e. actually realized) efficiency even in the simultaneous institution.<sup>9</sup>

#### 4.1.2 Success Rate

An alternative, and frequently employed, measure of efficiency is simply the rate of successful provision of the public good. This measure, however, fails to incorporate the importance of the way in which provision is successful or

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<sup>8</sup>For example, suppose six players select a contribution of 2 tokens and six players select a contribution of 4 tokens. These contributions are selected prior to the random partitioning of the population into three stage game populations of size four (note that six 4's and six 2's is a population-type equilibrium to the random matching game). A contribution of 2 is a best response (expected payoff-maximizing) against six 4's and five 2's and a contribution of 4 is a best response against six 2's and five 4's. The expected efficiency from a random allocation of 12 players into three groups of 4 players for a population of strategies of six 2's and six 4's is 69% (the probability of an efficient grouping of two 2's and two 4's is 0.48).

<sup>9</sup>We did this because it is likely that individual behavior is more affected by the outcomes reported to the individuals than the hypothetical possible outcomes.

unsuccessful according to the considerations discussed above, especially in the simultaneous institution. Therefore, we discuss success as an independent performance concept from efficiency.

## 4.2 Group Behavior

### 4.2.1 Efficiency and Success

Figures 1 and 2 show observed relative frequencies of outcomes in the different efficiency categories (aggregated over all rounds and sessions). These figures are for illustrative purposes only. While the majority, i.e. 62% of all groups, in the sequential institution without refund generate a 100% efficient outcome, a sequential institution alone is not enough to eliminate all inefficiencies. Introducing full refund, by design, eliminates all negative inefficiencies, however, it only slightly increases 100% efficiency to 64% (as seen in Figure 2).

FIGURE 1:  
OBSERVED FREQUENCIES OF GROUP EFFICIENCIES (NO REFUND)

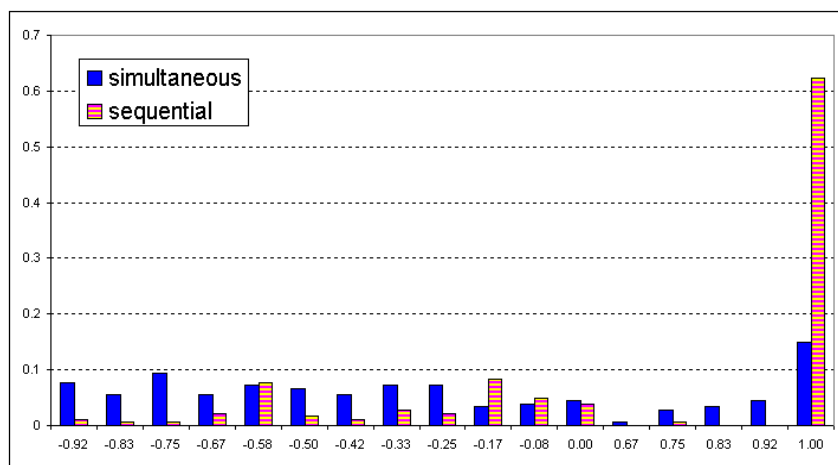
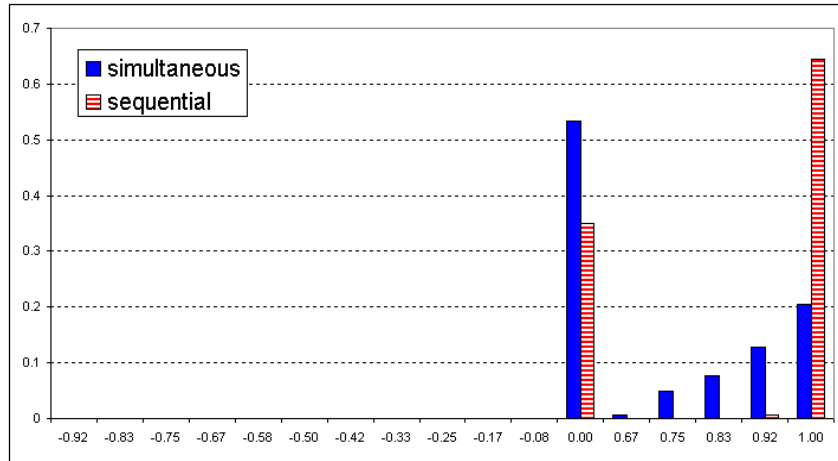


FIGURE 2:  
OBSERVED FREQUENCIES OF GROUP EFFICIENCIES (FULL REFUND)



Given that subjects participated in 20 rounds of public good games, we report efficiency and success rates separately for the first 10 and the last 10 rounds. Tables III and IV report on aggregate results (aggregated over all rounds as well as sessions). These are for illustrative purposes only and any statistical tests are done on session level data.

TABLE III:  
EFFICIENCY AND SUCCESS RATES  
(Simultaneous Contributions)

		Efficiency			Success		
		1–10	11–20	all	1–10	11–20	all
	Full	39.2%	46.6%	42.9%	43.3%	50.0%	46.7%
<i>Refund</i>	Refund						
<i>Policy</i>	No	-14.3%	-12.1%	-13.2%	25.6%	26.7%	26.1%
	Refund						

Conducting robust rank order tests on session level data for the observed efficiency in the simultaneous institution, we cannot reject our first hypothesis. Efficiency is higher in the simultaneous institution if a full refund is offered.<sup>10</sup> This holds true when comparing efficiency under the full refund

<sup>10</sup>For the non-parametric tests used in this paper see Siegel and Castellan (1988).

policy with efficiency under the no refund policy in the first ten rounds, the last ten rounds and all rounds together.<sup>11</sup>

TABLE IV:  
EFFICIENCY AND SUCCESS RATES  
(Sequential Contributions)

		Efficiency			Success		
		1–10	11–20	all	1–10	11–20	all
<i>Refund Policy</i>	Full	61.6%	68.3%	64.9%	61.7%	68.3%	65.0%
	Refund <sup>12</sup>						
	No	49.5%	50.7%	50.1%	62.2%	63.3%	62.8%
	Refund						

As for the sequential institution, we cannot reject our second hypothesis of efficiency being the same under either refund scheme, at least not, when comparing efficiency achieved in the last 10 rounds or all rounds together (robust rank order test,  $\hat{U} = -0.56695$  and  $\hat{U} = -1.28624$  respectively).<sup>13</sup> However, initial efficiency (over the first 10 rounds) is higher under the full refund policy than under the no refund policy (robust rank order test,  $\hat{U} = -2.91218$ ,  $p = 0.0036$ , two-tailed).

In order to test our third hypothesis, we first compare efficiency in both institutions under the full refund policy. We find that observed efficiency in the sequential institution is significantly higher than in the simultaneous institution with full refund. This holds true for the first 10 rounds, the last 10 rounds and all rounds together. The same holds if we compare efficiency in both institutions under the no refund policy.<sup>14</sup> However, if we compare

<sup>11</sup>In fact, efficiency in each single session under the full refund policy is higher than the highest efficiency ever achieved under the no refund policy. We do not report  $p$ -values associated with the approximately infinitely large test statistic.

<sup>12</sup>Note that efficiency in the sequential institution in the full refund case should, theoretically speaking, be identical to the success rate. This is almost the case. However, we observed 2 players, who were the last to choose in their group, to add 5 to a total sum 8 by the others, thereby overshooting the target by 1 token and losing some efficiency.

<sup>13</sup>The associated two-tailed  $p$ -values for both test statistics are greater than 0.20.

<sup>14</sup>Again, the lowest efficiency rate observed of all sessions in the sequential institution under full refund (no refund) is higher than the highest observed efficiency in the simultaneous institution under full refund (no refund).

the simultaneous institution with full refund with the sequential institution without refund, we do not find a significant difference (robust rank order test statistics are  $\hat{U} = -1.13067$ ,  $\hat{U} = 0.181902$  and  $\hat{U} = -0.53033$  for the first 10 rounds, the last 10 rounds and all rounds together, respectively).<sup>15</sup> We therefore cannot fully reject our third hypothesis. However, we should restate our findings. While the sequential institution unambiguously achieves more efficient outcomes than the simultaneous institution when comparing across the same refund policies, the refund policy is crucial. Sequential institutions per se do not dominate a full refund in achieving higher efficiency. We observe that the achieved efficiency of the sequential mechanism without a refund is not different from the achieved efficiency of the simultaneous mechanism with a full refund.

If the intention of designing one institution over another is to increase the number of times the public good is provided, we can resurrect our third hypothesis. Comparing success rates, instead of efficiency, we find that even a sequential institution with no refund unambiguously provides the public good more often.<sup>16</sup>

#### 4.2.2 Contributions

Table V illustrates average contribution in the simultaneous institutions with and without refund. It seems that average contributions are higher when full refund is offered, however, due to the high variance between sessions in the simultaneous institution without refund, this difference is not statistically significant (robust rank order test,  $\hat{U} = -0.33541$ ).

We find that the number of times that all four players choose a contribution of 3 is surprisingly low under either refund rule. As expected, risk aversion does not play a role under a full refund policy and we do not observe any groups where all players choose zero.

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<sup>15</sup>This is due to the high variance across sessions in the observed efficiency in the sequential institution without refund.

<sup>16</sup>This holds for the first 10 rounds as well as for all rounds together. A robust rank order test of the last 10 rounds alone does not find the difference to be significant ( $\hat{U} = -1.13067$ ). Note, however, that the refund policy never seems to make a significant difference when comparing success rates within institutions.

TABLE V:  
CONTRIBUTIONS  
(Simultaneous Institution)

	average contribution	# (0,0,0,0)	# (3,3,3,3)
Full refund	2.80	0	$\frac{11}{180}$
No refund	1.96	$\frac{8}{180}$	$\frac{18}{180}$

Table VI illustrates average contributions in the sequential institution. Average contributions are higher in the sequential institution with refund.<sup>17</sup> Interestingly, average contributions in the no refund treatment are much more symmetric across the four players in a group than in the treatment with refund. First players in the no refund treatment contribute significantly more than their equally positioned counterparts in the treatment with refund (robust rank order test,  $\hat{U} = 2.912176$ , one tailed  $p = 0.0018$ ). The same holds for second players (robust rank order test,  $\hat{U} = 2.544079$ , one tailed  $p = 0.0055$ ). Third and fourth players, however, contribute significantly more in the treatment with refund.<sup>18</sup> It seems as if equilibrium predictions are more born out when full refund is offered. One possible explanation could be that first players feel less guilty about contributing less in the full refund treatment because they know that later players will get their contributions reimbursed if the threshold is not met. This makes fairness considerations seem stronger in the case without refund. For a different interpretation of first player's behavior see Coats and Neilson (2005) who focus on reciprocity motivations.<sup>19</sup>

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<sup>17</sup>The lowest average contribution of all sessions with refund is higher than the highest contribution of all sessions without refund.

<sup>18</sup>The lowest average contribution of all sessions with refund is higher than the highest contribution of all sessions without refund for third as well as fourth players.

<sup>19</sup>Coats and Neilson (2005) interpret higher contributions of early movers in the sequential mechanism without a refund as avoidance of negative reciprocity of later movers. Early movers know that later movers have the capacity to punish low contributions under the no refund rule and hence contribute more in that case.

TABLE VI:  
CONTRIBUTIONS  
(Sequential Institution)

	average contribution	1st player	2nd player	3rd player	4th player
Full refund	2.71	1.36	2.11	3.37	4.02
No refund	2.26	2.08	2.42	2.18	2.37

### 4.3 Individual Behavior

The aggregate analysis above ignores any individual effects. We shall now report on random effects Tobit regressions.<sup>20</sup> See Appendix B for the details of the regression analyses. Table VII and VIII report on the results. The dependent variable is each participant’s contribution, naturally censored to lie between 0 and 5.

While most studies of non-threshold public goods find that contributions decline over time, we do not find that to be the case for our threshold public good game, neither under the simultaneous nor the sequential institution. We initially included “period” as an explanatory variable, but this did not improve the fit of the models (Likelihood Ratio Tests). We therefore decided to drop this explanatory variable.

Let’s first concentrate on the simultaneous institution and analyze differences in contributions depending on whether a refund is offered or not. We find that participants unambiguously contribute more when a full refund is offered, providing additional support for Hypothesis 1. We find that whether the public good was provided in the previous round or not does not affect contributions when no refund is offered, however, participants contribute more in the full refund case when the public good was successfully provided in the previous period. This seems to be driven by the lowest contributors in a

<sup>20</sup>We were not able to cluster for session level effects in the random effects Tobit regressions. However, an alternative random effects GLS regression does not account for the censoring of the data (naturally the contributions lie between 0 and 5). Since about one third of our data are censored, we decided to run random effects Tobit regressions. Additional error correlations within a session (which would be accounted for in a clustered regression) should only affect the efficiency and not the significance of our estimates.

group. While those low contributors usually decrease their contributions in a subsequent round, the decrease is significantly smaller in the full refund case. Interestingly, the highest contributors in a group usually contribute more in a subsequent round, however at a lower rate in the full refund case. Contributions in the full refund case get an additional boost when the public good was successfully provided in the previous round, i.e. contributions are higher in any subsequent round which is not the case when no refund is offered.<sup>21</sup>

TABLE VII:  
RANDOM EFFECTS REGRESSION RESULTS  
(Simultaneous Institution)

RE Tobit			
constant	1.9867**		
	(0.0756273)		
refund	0.3996**		
	(0.1046488)		
prev_suc	3.4021	i_refund_suc	0.5410*
	(0.1923685)		(0.2343418)
lowest	-2.0580**	i_refund_low	1.0976**
	(0.1987207)		(0.2111576)
highest	1.7002**	i_refund_high	-0.7392**
	(0.197732)		(0.2010644)
-log likelihood	1917.2704		
Wald $\chi^2$	518.56**		
left-censored	255		
right-censored	81		
uncensored	1032		

Note: \*\* (\*) denotes 1% (5%) significance,  
bootstrapped standard errors are given in parentheses.

We included the order in which participants pledge their contributions in our random effect estimations for the sequential institution. For each

<sup>21</sup>Theory does not predict such an effect. However, reinforcement models (e.g., Roth and Erev, 1995) would tend to predict such behavior. Interestingly, contributing behavior does not get reinforced in the case when risk aversion might play a role (i.e. without refund).

position we created a dummy variable and interacted the position with the refund variable. We find that the refund influences contributions differently for first movers and later ones. We find that while third and fourth movers contribute more under either refund rule, they contribute even more under full refund. This also holds for second movers who contribute significantly more under full refund. Whether the public good was provided successfully seems to only matter in the full refund case where participants tend to decrease their contributions after a successful provision.

TABLE VIII:  
RANDOM EFFECTS REGRESSION RESULTS  
(Sequential Institution)

RE Tobit			
constant	1.3343**		
	(0.2638)		
refund	-0.3671		
	(0.3247)		
prev_suc	0.1386	i_refund_suc	-0.4661*
	(0.1967)		(0.2250)
second	0.3032	i_refund_second	0.9496**
	(0.2498)		(0.3076)
third	1.3029**	i_refund_third	1.6324**
	(0.4248)		(0.4818)
fourth	1.6454**	i_refund_fourth	2.6172**
	(0.4413)		(0.5110)
-log likelihood	3523.0433		
Wald $\chi^2$	245.89**		
left-censored	360		
right-censored	413		
uncensored	1279		

Note: \*\*(\*) denotes 1% (5%) significance,  
bootstrapped standard errors are given in parentheses.

## 5 Discussion

We analyze how voluntary contributions to a threshold public good are affected by institutional characteristics of the voluntary contribution mechanism. In particular, we compare efficiency in the case of simultaneous and sequential contributions. For each order of contributions, we investigate how a full refund rule affects efficiency as compared to a no refund rule. We find that, given a refund rule, the sequential contribution mechanism unambiguously induces higher contributions and achieves a higher efficiency than the simultaneous mechanism. For the no refund rule, this extends the results of Erev and Rapoport (1990), who find this to be the case for binary contributions, to a variable contribution setting. Our results are novel for the full refund case. We show that a sequential contribution mechanism yields higher efficiency and provides the public good more often when a full refund is offered than a simultaneous contribution mechanism with the same refund rule.

For a given order of contributions, we find that the introduction of a full refund reduces the variance in contributions. For both orders we find significantly higher efficiency in the case with full refund. These results support what others have found (i.e. Isaac, Schmidtz and Walker, 1989) for similar simultaneous contribution games. We show that those results extend to sequential contribution games. Surprisingly, and contrary to the theoretical predictions, the refund rule matters in the sequential games. We find that, while still not a perfect point predictor, the unique subgame perfect equilibrium predictions are born out more in the case with full refund. It seems that early movers are influenced by other-regarding preferences and the expectations of such preferences. This explanation is different from a risk averse explanation behind the effect of full refund in the simultaneous game. There, risk averse participants contribute because they do not have to fear losing money. It seems that the expectation of others being risk averse and concerned with fairness make early movers contribute less in the case of full refund and more otherwise. The risk aversion explanation for the simultaneous game still holds for later movers in the sequential game. These later movers contribute more when full refund is offered.

## Appendix A: Experimental Interface

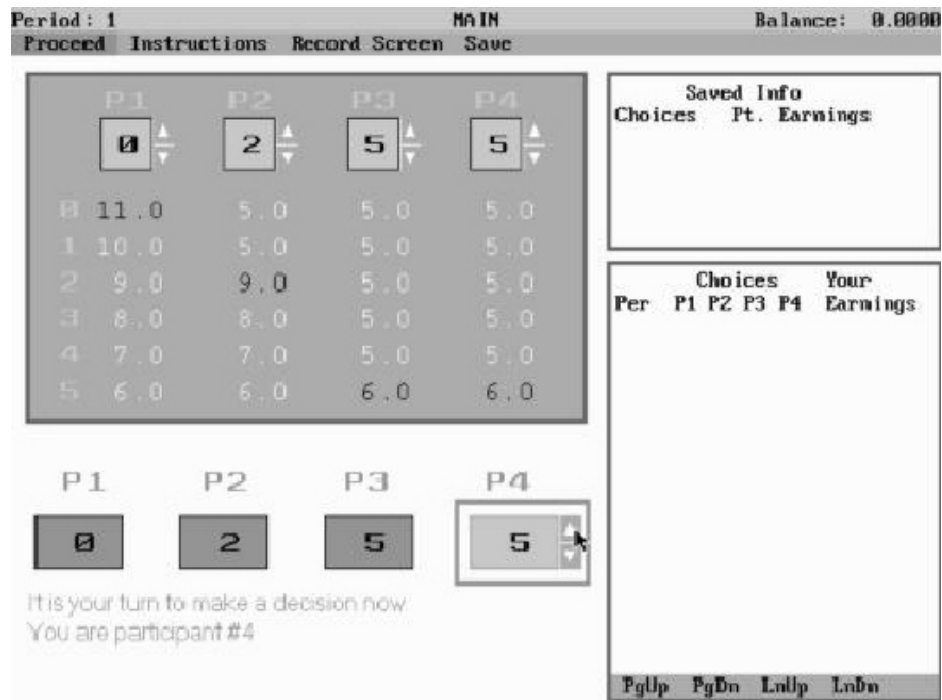


Figure 1: Example of Main Screen (here sequential with full refund)

## Appendix B: Details of Estimations

### B1. Explanatory Variables

The dependent variable was each participant's **contribution**, naturally censored to lie between 0 and 5. The following are the explanatory variables that we used for our simultaneous treatments.

**refund** Equals 1 in full refund treatment, 0 otherwise.

**prev\_suc** Equals 1 if the public good was provided in the previous period.

**lowest** Equals 1 if participant made lowest group contribution in the previous period.

**highest** Equals 1 if participant made highest group contribution in the previous period.

**i\_refund\_variable** Stands for the interaction term between **refund** and the variable mentioned.

We started off by also including **period** (1 – 20) and **prev\_free** (equal to 1 if participant freerode in previous period) as explanatory variables. However, likelihood ratio tests confirmed that the restrictions of **period** and/or **prev\_free** being equal to 0 could not be rejected. We therefore did not include these variable in the estimations that we report.

For the sequential institution we also included the order in which participants made their contributions. We created dummy variables for the different positions in which participants made their choices.

**second** Equals 1 if participant was second in line.

**third** Equals 1 if participant was third in line.

**fourth** Equals 1 if participant was fourth in line.

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