Supplementary Materials for: Enforcement of Contribution Norms in Public Good Games with Heterogeneous Populations

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Abstract

This document contains supplementary materials for the paper *Enforcement of Contribution Norms in Public Good Games with Heterogeneous Populations*. It is organized in the following way: Section 1 consists of a sample of the instructions used in the experiment and in the online questionnaire study, Section 2 contains the results of nonparametric comparisons between treatments, Section 3 provides a detailed description of the frequency of periods with maximal contributions, Section 4 presents the regressions of the various robustness checks for the norm-elicitation technique reported in the paper, and Section 5 provides regressions that illustrate the reaction in contributions to being punished.

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1 Instructions

In this section, we provide a sample of the instructions used in the experiment and in the online questionnaire study. The instructions below are a translation of the original instructions, which are in Dutch.

1.1 Experiment

The experimental instructions correspond to those given to high players in the UMB treatment with punishment. Instructions used for low players, for groups without punishment, and in the other group types are very similar and available upon request. Note that respondents in the questionnaire study were given a copy of the instructions observed by subjects in the experiment. Questionnaire respondents saw the instructions of the group type to which they had been randomly assigned. Moreover, they saw instructions only for groups without punishment.

Introduction

This experiment is divided into different periods. There will be 10 periods in total. During all 10 periods, the participants are divided into groups of three. Therefore, you will be in a group with 2 other participants. The composition of the groups will remain the same during all of the experiment.

Each period consists of two stages. In the first stage, you have to decide how many tokens you contribute to a group project. In the second stage, you will learn how much the other members of your group contributed to the project.

The first stage

At the beginning of each period each participant in your group receives 20 tokens. We will refer to these tokens as the initial endowment.

In the first stage you decide how to use your initial endowment. You have to choose how many tokens you want to contribute to a group project and how many of them to keep for yourself. You can contribute any amount of your initial endowment to the group project. How many tokens you contribute is up to you. Each other group member will also make such a decision. All decisions are made simultaneously. That is, nobody will be informed about the decision of the other group members before everyone made his or her decision.

Earnings in the first stage

Your earnings in tokens, in each period, are the sum of two parts:

- The number of tokens that you kept for yourself.
- Your income from the group project. This income equals:

$$[\text{multiplication factor}] \times \text{sum of contributions of all group members to the project}$$

The projects' multiplication factor is determined as follows: in each group, *one of the group members will have a multiplication factor of 0.75* and the other *two group members will have a multiplication factor of 0.5.* Before the experiment started each desk was assigned a multiplication factor equal to either 0.5 or 0.75. Therefore, by randomly assigning the yellow cards, each participant was randomly assigned to one of these values. The multiplication factor will be the same for all the 10 periods. *You will be the group member who has a multiplication factor of 0.75.*

Notice that, for each token which you keep for yourself you earn 1 token. If instead you contribute this token to the group project, then the total contribution to the project will rise by one token. Your income from the group project will rise by 0.75 tokens. Moreover, the other group members' income from the project will rise by 0.5 tokens. Your contribution to the group project therefore also raises the income of the other group members. For each token contributed to the project the total earnings of the group will rise by 1.75 tokens. Note that, you also earn tokens for each token contributed to the group project by the other group members. For each token contributed by any member you earn 0.75 tokens.

In summary, your earnings in tokens at the first stage of a period are equal to:

$$20 - \text{your contribution} + \text{your multiplication factor} \times (\text{sum of contributions})$$

After everyone has made his or her decision the first stage ends.

Example for the first stage

Here is an example that illustrates how the earnings in tokens are calculated in the first stage of each period. The numbers used in the example are arbitrarily chosen.

You are in a group with two other participants (group member 1 and group member 2). Each participant's multiplication factor equals: you = 0.75, group member 1 = 0.5, group member 2 = 0.5. Suppose that, you contribute 15 tokens to the group project, group member 1 contributes 5 tokens to the group project, and group member 2 contributes 10 tokens to the group project. The earnings in tokens of each of the participants are given by:

$$20 - \text{tokens contributed} + \text{multiplication factor} \times \text{sum of all contributions}$$

In your case this equals: $20 - 15 + 0.75 \times (15 + 5 + 10) = 27.5$ tokens.

For group member 1 this equals: $20 - 5 + 0.5 \times (15 + 5 + 10) = 30$ tokens.

For group member 2 this equals: $20 - 10 + 0.5 \times (15 + 5 + 10) = 25$ tokens.

The second stage

At the beginning of the second stage, everyone in the group will see how much each of the other group members contributed to the project as well as their earnings from the first stage. The decision each group member has to make in the second stage is to either reduce or leave equal the earnings of each other group member. Reducing other group members' earnings can be done by spending tokens. The other group members can also reduce your earnings if they wish to. All decisions are made simultaneously. That is, nobody will be informed about the decision of the other group members before everyone made his or her decision.

More concisely, in this stage, you must decide whether and if yes how many tokens you want to spend to reduce the earnings of the other two group members. If you want to reduce another member's earnings, you do that by allocating deduction points. For each deduction point that you allocate to another group member his or her earnings are reduced by 3 tokens and your own earnings are reduced by 1 token. If you do not wish to change the earnings of another group member then you must allocate 0 deduction points to him or her. Note, that you will not be allowed to reduce the earnings of a group member to less than zero.

Remember that, for every deduction point you receive from other group members, your earnings will be reduced by 3 tokens (but never below zero). Every participant can spend up to a maximum of 10 tokens (i.e. allocate 10 deduction points) on each group member in each period.

After everyone has made a decision, you will be informed how many deduction points you received from the other group members and also what your total earnings in tokens for that period are. Note that you do not get to know how individual group members spend their deduction points. In other words, you will only be informed of the total amount of deduction points allocated to you by the other two group members. You will not know how many deduction points each individual group member allocated to you.

Examples for the second stage

Here are some arbitrarily chosen examples that illustrate how your final earnings are calculated. You, group member 1 and group member 2 are all members of the same group.

Example 1: Suppose that after the first stage you have earnings that are equal to 30 tokens. In the second stage you decide to allocate 3 deduction points to group member 1 (this reduces group member 1's earnings by 9 tokens) and 0 deduction points to group member 2 (this does not change group member 2's earnings). After all have made their decision, you learn that the others allocated you a total of 4 deduction points. In this case, your total earnings in tokens in this period are given by:

(Your first stage earnings - 3 $\times$ deduction points allocated to you)*
- deduction points you allocated

* If the number between brackets is negative then replace it with zero.
In this example, your earnings are equal to: $(30 - 3 \times 4) - 3 = 18 - 3 = 15$ tokens.

Example 2: Suppose that after the first stage you have earnings that are equal to 18 tokens. In the second stage you decide to allocate 4 deduction points to group member 1 (this reduces group member 1's earnings by 12 tokens) and 6 deduction points to group member 2 (this reduces group member 2's earnings by 18 tokens). After all have made their decision, you learn that the others allocated you a total of 8 deduction points.
In this case, your earnings are equal to: $(18 - 3 \times 8) - 10 = 0 - 10 = -10$ tokens.
Note that $18 - 3 \times 8 = -6$, since this is a negative number it is replaced by zero.

Negative earnings
It is, in principle, possible that you make negative earnings in a period. However, you can always avoid this by not spending any tokens in the second stage (that is, by not allocating any deduction points to the other members). Hence, you can always avoid negative earnings with certainty through your own choices.

Summary
In summary, your earnings in tokens in each period are equal to:

(Your initial endowment - your contribution to the project
+ 0.75 $\times$ (sum of contributions)
- 3 $\times$ total deduction points received from others)*
- amount of deductions points you allocated to others

* If your earnings up to this point are negative then replace them with zero

1.2 Online questionnaire study

The questionnaire study consisted of two sets of questions. The first set corresponds to the following question:

"From the viewpoint of a *neutral uninvolved arbitrator*, what is the ***fair*** amount that each of the group members should contribute to the group project?

Group member 1 (has an endowment of y_1 tokens and can contribute up to $\bar{c}_1$ tokens): ______

Group member 2 (has an endowment of y_2 tokens and can contribute up to $\bar{c}_2$ tokens): ______

Group member 3 (has an endowment of y_3 tokens and can contribute up to $\bar{c}_3$ tokens): ______ "

Respondents indicated a contribution for each group member and could choose any contribution between 0 and $\bar{c}_i$. The second set corresponds to a series of questions of the following form:

"From the viewpoint of a *neutral uninvolved arbitrator*, what is the ***fair*** amount that group member i and group member j should contribute if: *group member k contributes **x tokens** to the group project*?

Group member i (has an endowment of y_i tokens and can contribute up to $\bar{c}_i$ tokens): ______

Group member j (has an endowment of y_j tokens and can contribute up to $\bar{c}_j$ tokens): ______ "

Respondents indicated a contribution for group members i and j and could choose contributions between 0 and respectively $\bar{c}_i$ or $\bar{c}_j$. We varied the values of x and the role of group members k, i, and $j \in \{1, 2, 3\}$ in order to identify different relative contribution norms. The specific roles and the answers that most-closely correspond to each norm are provided in Table A1. Note that for all group types, $x = 16$ tokens in the first question and $x = 8$ tokens in the remaining questions.[1]

In the main body of the paper, when we evaluate the answers to the second set of questions we use a classification that does not allow for error. That is, if a response does not conform to the *exact* values in Table A1 it is categorized as 'other'. In Table A2 we present the fraction of answers that coincides with the discussed relative contribution rules when we allow for a small error of ± 1 in each response.[2] As in the paper, it also reports the fraction of answers consistent with the efficiency rule and the fraction that is not consistent with any of the discussed rules. Lastly, in cases where various rules inevitably overlap (as they do in EQUAL),

[1] In addition to these questions, the questionnaire had "filler" questions so that respondents could not discern the purpose of the study. These questions are available upon request.

[2] Allowing for larger errors produces considerable overlap between the different contribution rules.

Table A1: Online questionnaire study questions

Note: Parameters for the second set of questions in the questionnaire study and the answers that most closely correspond to each contribution norm. Note that for all group types, the contribution of group member k is fixed to $x = 16$ tokens in question 1 and $x = 8$ tokens in questions 2 and 3.

				Contribution *most* consistent with				
				Equality of		*Proportionality to*		
Group type	*Question #*	*Group member*	*Role*	*contributions*	*earnings*	*endowments*	*benefits*	*Efficiency*
EQUAL	1	i	low	16	–	–	–	20
		j	low	16	–	–	–	20
	2	i	low	8	–	–	–	20
		j	low	8	–	–	–	20
URE	1	i	low	16	0	8	–	20
		j	low	16	0	8	–	20
	2	i	low	8	0	4	–	20
		j	low	8	0	4	–	20
	3	i	high	8	20	16	–	20
		j	low	8	8	8	–	20
UUE	1	i	low	16	0	8	–	20
		j	low	16	0	8	–	20
	2	i	low	8	0	4	–	20
		j	low	8	0	4	–	20
	3	i	high	8	28	16	–	40
		j	low	8	8	8	–	20
UMB	1	i	low	16	8	–	11	20
		j	low	16	8	–	11	20
	2	i	low	8	4	–	5	20
		j	low	8	4	–	5	20
	3	i	high	8	16	–	12	20
		j	low	8	8	–	8	20

we assign the answers to the equal contributions column and leave the others blank.

As can be seen in the table, allowing for some error does not change the paper's qualitative results. First, a large majority of respondents indicate contributions that are consistent with at least one of the discussed relative contribution rules. Second, in homogeneous groups there is widespread agreement on the equal contribution rule. Third, in heterogeneous groups there is no consensus on a contribution rule (i.e., all rules have less than half of the responses). Fourth, the appeal of the different relative contribution rules varies with the type of group

Table A2: Fraction of answers coinciding with selected contribution rules

Note: Fraction of answers to the second set of questions in the questionnaire study that coincides with the contribution rules discussed in the paper, allowing for an error of ± 1 for each response. In group types where various rules overlap answers are assigned to the equal contributions rule.

Group type	*Equality of contributions*	*Proportional to endowments*	*Proportional to benefits*	*Equality of earnings*	*Efficiency*	*Other*
Equal	0.76	–	–	–	0.13	0.11
URE	0.32	0.27	–	0.14	0.03	0.24
UUE	0.13	0.41	–	0.26	0.02	0.18
UMB	0.16	–	0.38	0.33	0.00	0.13

heterogeneity. In URE the modal normative rule is still equal contributions while in UUE it is contributions proportional to the (unequal) endowments. The more noticeable difference is seen in UMB where proportionality becomes the most prominent choice.

2 Statistical comparisons across treatments

In this section we report the results of comparing contributions, punishment, and earnings of high and low players across the different group types.

As seen in the paper, with out punishment average contributions of high and low players *across* group types are very similar. We corroborated this impression with Kruskal-Wallis tests that compare the contributions of each player role across all treatments without punishment. We do not reject the hypothesis that the contributions of low players are drawn from the same distribution ($p = 0.409$; $p = 0.374$ in the last five periods) or the hypothesis that the contributions of high players are drawn from the same distribution ($p = 0.797$; $p = 0.711$ in the last five periods). By contrast, with punishment we observe clear differences in the behavior of high players *across* group types. A Kruskal-Wallis test rejects the null hypothesis that the contributions of high players are drawn from the same distribution ($p = 0.002$). Pair-wise comparisons reveal that the contributions of high players in UUE are significantly different from those of high players in URE and UMB (RRO tests, $p \leq 0.001$). For low players, a Kruskal-Wallis test does not reject the null hypothesis that contributions come from the same distribution ($p = 0.241$).

In the paper, we can see that punishment behavior is similar *across* group types and roles. Indeed, Kruskal-Wallis tests do not reject the hypothesis that punishment points are drawn from the same distribution for all group types, irrespective of whether we look at overall punishment ($p = 0.967$), punishment from low players to low players ($p = 0.317$), low players to high players ($p = 0.903$), or high players to low players ($p = 0.541$).

As the last part of this analysis, we test whether the enforcement of contribution norms in homogeneous and heterogeneous groups increases material welfare. For this to be true, it must be the case that contributions are high enough to compensate for the material loses caused by the costs of giving and receiving punishment. If we look at all periods, we see that earnings are very similar in groups with and without punishment (on average, 24.0 vs. 22.1 points in Equal, 29.9 vs. 30.5 points in URE, 32.1 vs. 30.7 points in UUE, 24.9 vs. 26.8 points in UMB). RRO tests confirm that earnings differences are not statistically significant in any group type (RRO tests, $p > 0.455$). However, we do observe that punishment produces a very different trend in average earnings over periods. In groups without punishment, earnings significantly decrease in all group types (Page's $\rho \leq -0.534$, $p \leq 0.001$), whereas in groups with punishment earnings significantly increase in all group types (Page's $\rho \geq 0.215$, $p \leq 0.050$). If these trends continue for many periods, as they do in Gächter et al. (2008) for homogeneous groups, punishment will deliver higher long-run earnings in all group types. Indeed, if we concentrate on the last five periods, we find higher earnings with punishment than without in all group types (on average, 25.4 vs. 21.1 points in Equal, 30.1 vs. 29.0 points in URE, 34.4 vs. 29.1 points in UUE, 25.4 vs. 25.3 points in UMB), although they are significantly higher only in Equal and UUE (RRO tests, $p \leq 0.050$). On closer inspection, it turns out that this is because of a smaller decrease over time in the amount of punishment in URE and UMB compared to Equal and UUE (Page's ρ between punishment points and periods equals -0.122 and -0.182 for the former and -0.346 and -0.369 for the latter). This result could be due to subjects taking more periods to settle on the enforcement of one of the (conflicting) relative contribution rules. In this sense, it is telling that punishment increases earnings more in UUE, where there is only a conflict between equality and equity, compared to URE and UMB, where there is an additional conflict between different interpretations of equity.

3 Maximal contributions and efficient groups

In this section we describe in more detail the distribution of periods with maximal contributions and how it relates to our definition of efficient and inefficient groups. Overall, maximal contributions by all group members occur in 31 percent of all periods. In Equal it is 37 percent, in URE and UUE it is 32 percent, and in UMB it is 24 percent. In contrast, in treat-

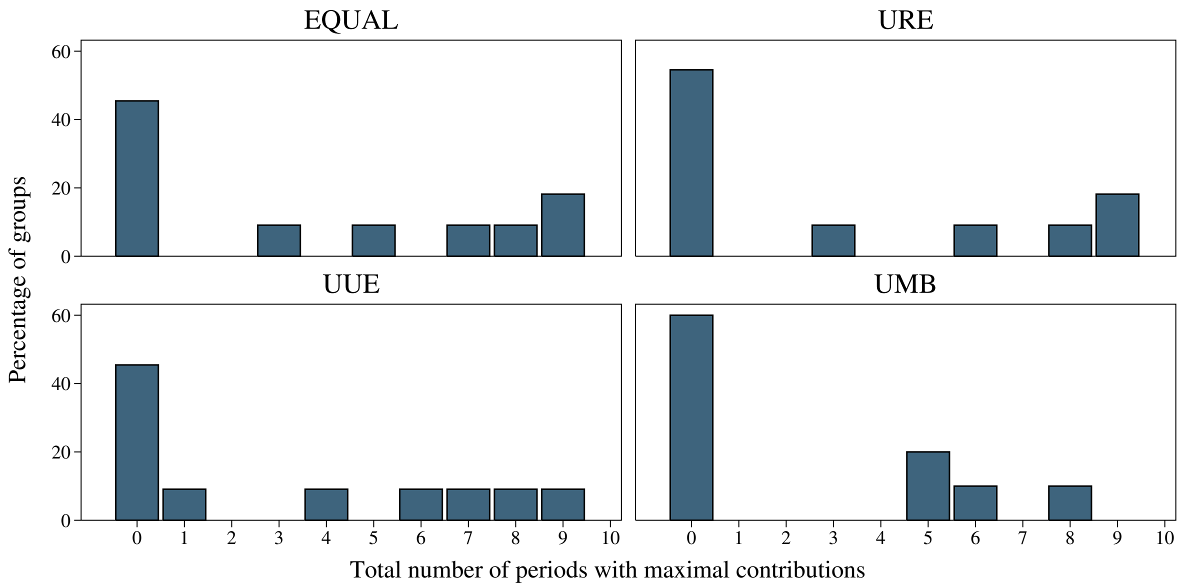

Figure A1: Distribution of periods with maximal contributions

Note: Distribution of the number of periods per group in which all group members contribute maximally to the public good. Data correspond to treatments with punishment.

ments without punishment everyone contributing maximally occurs in less than 2 percent of all periods.

Interestingly, within each treatment, periods with maximal contributions are found only in a few matching groups. This finding is depicted in Figure A1, which shows for each treatment the distribution of the number of fully efficient periods per group. As can be seen from the figure, between 45 percent (Equal) and 60 percent (UMB) of the groups with punishment never achieve maximal contributions. By contrast, most groups that do reach maximal contributions usually do so for a considerable number of periods (on average, 6.43 periods).

We also find that periods with maximal contributions tend to occur consecutively and later in the game. Specifically, among groups that reach full efficiency at least once, Page's correlation coefficient between the period number and a binary variable indicating whether the group attained maximal contributions or not in a given period is positive and significant in Equal, URE, and UUE ($\rho \geq 0.287$, $p \leq 0.050$) and shows the same pattern in UMB ($\rho = 0.242$, $p \geq 0.146$). Moreover, regressing the same binary variable on its one-period lag indicates that the probability that a period displays maximal contributions is significantly increased if it is preceded by a period with maximal contributions (the probability increase ranges from 25 percentage points in UMB to 59 percentage points in UUE, $p \leq 0.008$ with probit estimates and clustering on groups).

4 Coefficients of the best-fitting regressions

In this section, we report the robustness checks of the econometric procedure used to evaluate the subjects' sanctioning behavior. As in the results section of the paper, we report the values of $\mu^{*H\to L}$, $\mu^{*L\to H}$, and $\mu^{*L\to L}$ that best describe the punishment data and the corresponding regression estimates.

Table A3 contains the values of $\mu^{*H\to L}$, $\mu^{*L\to H}$, and $\mu^{*L\to L}$ that best describe the punishment data when we estimate the μ's using data from all the groups (i.e., both efficient and inefficient groups). The table also contains the coefficients of the corresponding Tobit regres-

Table A3: Best fitting contribution norms using all groups

	Optimal μ's			
	Equal	URE	UUE	UMB
$\mu^{*H\to L}$		0.51	0.33	0.48
$\mu^{*L\to H}$		0.54	0.68	0.51
$\mu^{*L\to L}$	0.51	0.52	0.50	0.51
	Regressions			
	Equal	URE	UUE	UMB
$\beta^{H\to L}_{pos}$		0.72**	0.07	0.92**
		(0.20)	(0.17)	(0.30)
$\beta^{H\to L}_{neg}$		0.65**	0.60**	0.68**
		(0.17)	(0.23)	(0.19)
$\beta^{L\to H}_{pos}$		0.26	0.46†	0.13
		(0.19)	(0.27)	(0.17)
$\beta^{L\to H}_{neg}$		0.66**	0.45*	0.75*
		(0.19)	(0.20)	(0.33)
$\beta^{L\to L}_{pos}$	0.07	0.42*	0.39	0.28
	(0.11)	(0.21)	(0.33)	(0.23)
$\beta^{L\to L}_{neg}$	0.64**	0.89**	1.15**	0.76**
	(0.15)	(0.18)	(0.29)	(0.19)
λ	0.12†	0.26**	0.18**	0.22**
	(0.06)	(0.06)	(0.06)	(0.07)
γ^r	0.14†	0.29**	0.17	0.17
	(0.08)	(0.07)	(0.11)	(0.12)
γ^p	–0.11	–0.03	–0.31**	–0.07**
	(0.07)	(0.08)	(0.10)	(0.07)
# obs.	594	594	594	540
log likelihood	–400.13	–365.15	–367.50	–439.68

Table A4: Best fitting contribution norms using probit estimates

	Optimal μ's			
	Equal	URE	UUE	UMB
$\mu^{*H\to L}$		0.52	0.36	0.48
$\mu^{*L\to H}$		0.51	0.69	0.51
$\mu^{*L\to L}$	0.52	0.50	0.50	0.52
	Regressions			
	Equal	URE	UUE	UMB
$\beta_{pos}^{H\to L}$		0.13	0.04	0.29^{*}
		(0.10)	(0.07)	(0.14)
$\beta_{neg}^{H\to L}$		0.23^{*}	$0.18^{\dagger}$	0.60^{**}
		(0.09)	(0.10)	(0.17)
$\beta_{pos}^{L\to H}$		0.06	0.13	0.00
		(0.09)	(0.16)	–
$\beta_{neg}^{L\to H}$		0.28^{*}	$0.13^{\dagger}$	0.64^{**}
		(0.12)	(0.07)	(0.25)
$\beta_{pos}^{L\to L}$	0.00	$0.18^{\dagger}$	0.00	0.28
	–	(0.10)	–	(0.18)
$\beta_{neg}^{L\to L}$	0.14^{*}	0.63^{**}	0.35^{**}	0.51^{**}
	(0.07)	(0.16)	(0.11)	(0.17)
λ	0.08^{*}	$0.06^{\dagger}$	0.06^{**}	0.08^{*}
	(0.03)	(0.03)	(0.02)	(0.03)
γ^{r}	0.17^{**}	$0.09^{\dagger}$	0.03	0.14^{*}
	(0.05)	(0.05)	(0.04)	(0.06)
γ^{p}	-0.07^{*}	-0.10^{*}	$-0.07^{\dagger}$	–0.03
	(0.03)	(0.04)	(0.04)	(0.04)
# obs.	324	378	378	324
log likelihood	–160.60	–124.15	–146.79	–164.98

sions. In Table A4, we report the regressions obtained when searching for the optimal μ's using probit as opposed to Tobit estimates (with inefficient groups only) where the decision consists of either punishing (= 1) or not punishing (= 0). All regressions are run with subject random effects, and in addition to the shown coefficients, they all contain group dummies, a constant, and dummies indicating the role of i and j. Standard errors are reported in parentheses, and statistical significance at the 10, 5, and 1 percent levels are indicated by the symbols †, *, **, respectively.

Overall, the regressions in Tables A3 and A4 are qualitatively the same to in the main body of the paper (in Table 6). Results are also quantitatively similar. In the following sentences we describe any important differences between the various specifications. Both tables reveal that using data from all groups does not markedly alter the optimal μ's in EQUAL, URE, and UUE. In contrast, in UMB we find that $\mu^{*H\to L}$, $\mu^{*L\to H}$, and $\mu^{*L\to L}$ all are close to 0.50, which is consistent with the enforcement of an equal contributions norm. With respect to the estimated regression coefficients, the only noticeable difference between Table 6 in the main body of the paper and the tables in this appendix occurs for the case where we use probit regressions. Namely, in Table A4 the coefficient measuring negative deviations from the efficiency rule (λ) in URE, and two coefficients measuring deviations from the relative contribution rule in UUE ($\beta_{neg}^{H\to L}$ and $\beta_{neg}^{L\to H}$) are now statistically significant only at the 10 percent level.

5 Reaction to punishment

In this section, we analyze how subjects change their contributions given the enforced contribution rule. We assume that the change in contributions of subject i depends on how much i's contribution deviates from the relative contribution rule and on whether i was punished. Specifically, we estimate the following two models in each group type:

Model I:

$$\begin{aligned} c_{it+1} - c_{it+1} = & \beta_{neg} \sum_{j \neq i} \max\left[(1-\mu^{i\to j})c_{jt} - \mu^{i\to j} c_{it}, 0\right] \\ & + \beta_{pos} \sum_{j \neq i} \max\left[\mu^{i\to j} c_{it} - (1-\mu^{i\to j})c_{jt}, 0\right] \\ & + \gamma^{Pun} Pun_{it} + \gamma^{p} t + \alpha + \upsilon_i + \epsilon_{it} \end{aligned}$$

Model II:

$$\begin{aligned} c_{it+1} - c_{it+1} = & \beta_{neg}^{NoPun}(1-Pun_{it}) \sum_{j \neq i} \max\left[(1-\mu^{i\to j})c_{jt} - \mu^{i\to j} c_{it}, 0\right] \\ & + \beta_{neg}^{Pun} Pun_{it} \sum_{j \neq i} \max\left[(1-\mu^{i\to j})c_{jt} - \mu^{i\to j} c_{it}, 0\right] \\ & + \beta_{pos}^{NoPun}(1-Pun_{it}) \sum_{j \neq i} \max\left[\mu^{i\to j} c_{it} - (1-\mu^{i\to j})c_{jt}, 0\right] \\ & + \beta_{pos}^{Pun} Pun_{it} \sum_{j \neq i} \max\left[\mu^{i\to j} c_{it} - (1-\mu^{i\to j})c_{jt}, 0\right] \\ & + \gamma^{Pun} Pun_{it} + \gamma^{p} t + \alpha + \upsilon_i + \epsilon_{it} \end{aligned}$$

The variable $c_{it+1} - c_{it+1}$ is the change in contributions from from period t to $t+1$ of a subject i. In Model I, the first two terms capture the effect of deviations from i's prescribed contribution according to the relative contribution rule represented by $\mu^{i \to j} \in [0, 1]$. The value of $\mu^{i \to j} c_{it} - (1 - \mu^{i \to j}) c_{jt}$ indicates how much the contribution of i deviates from i's prescribed contribution given j's contribution c_{jt}. If this value is positive then i contributed too much and if it is negative i contributed too little. Consequently, the first term in Model I captures the effect of negative deviations from the contribution rule and the second term captures positive deviations (i.e., we allow for different reactions to positive and negative deviations from the rule). When we run the regressions, for each group type, we use the estimated values of $\mu^{*H \to L}$, $\mu^{*L \to H}$, and $\mu^{*L \to L}$ seen in Table 5 in the main body of the paper. The third term in the equations, Pun_{it} is a dummy variable equal to one if subject i was punished in period t and zero otherwise. The next term is simply the period number, t, which captures other motivations such decreasing contributions in later periods due to endgame effects. Finally, α corresponds to the constant, υ_i to unobserved individual characteristics treated as random effects, and ϵ_{it} is the error term. Model II is the same as Model I except that we interact the dummy variable Pun_{it} with the variables measuring i's deviation from the contribution rule. Hence, Model II allows subjects to react differently to punishment depending on whether they had deviated positively or negatively from the prescribed contribution. The estimated coefficients for both models and each group type are presented in Table A5. In all cases we restrict the regressions to inefficient groups because these are the groups that were used to estimate the values of $\mu^{*H \to L}$, $\mu^{*L \to H}$, and $\mu^{*L \to L}$.

By and large, the regression results presented in Table A5 are quite intuitive. By looking a Model I we can see that in all group types, subjects who on average contribute less than the contribution rule prescribes significantly increase their contribution in the following period, and analogously, subjects who contribute more than the contribution rule prescribes significantly decrease their contribution. In Model I, being punished does not significantly impact contributions, which shows that being punished *per se* does not lead to an increase in contributions. This result can be explained by the reaction to punishment depending on the subjects' compliance with the contribution rule. Whether this is the case can be seen in Model II.

In Model II, we observe that in all group types subjects who are punished and contribute less than their prescribed contribution significantly increase their contribution in the next period. By contrast, subjects who are not punished and contribute less than their prescribed contribution significantly increase their contribution only in URE and UMB. Unlike punishment of negative deviations, punishment of positive deviations leads to a decrease in contributions (significant in EQUAL, URE, and UMB). Lastly, the coefficient for the period number is generally significantly negative, suggesting that without punishment there would be a decline of contributions.

Table A5: Change in contributions

	EQUAL		URE		UUE		UMB	
	I	II	I	II	I	II	I	II
γ^{Pun}	0.06	–0.49	–0.04	1.10	1.77	–1.84	–0.42	0.48
	(0.82)	(1.15)	(0.70)	(1.29)	(1.11)	(1.84)	(0.57)	(0.91)
β_{neg}	0.49**		0.34**		0.51*		0.50**	
	(0.14)		(0.11)		(0.22)		(0.15)	
β_{pos}	–0.41**		–0.61**		–0.51**		–0.54**	
	(0.16)		(0.11)		(0.16)		(0.09)	
β_{neg}^{NoPun}		–1.58*		0.31*		0.12		0.93**
		(0.79)		(0.15)		(0.26)		(0.24)
β_{neg}^{Pun}		0.51**		0.32*		0.70**		0.33*
		(0.15)		(0.15)		(0.20)		(0.17)
β_{pos}^{NoPun}		–0.44*		–0.47**		–0.78**		–0.51**
		(0.22)		(0.14)		(0.19)		(0.12)
β_{pos}^{Pun}		–0.58*		–0.81**		–0.10		–0.57**
		(0.23)		(0.17)		(0.22)		(0.10)
γ^{p}	–0.33*	–0.39**	–0.30*	–0.31*	–0.32	–0.35†	–0.17†	–0.18†
	(0.15)	(0.15)	(0.14)	(0.14)	(0.20)	(0.20)	(0.10)	(0.09)
Constant	–0.16	0.57	1.28†	0.77	–0.01	1.57	1.39†	0.91
	(0.70)	(0.87)	(0.74)	(0.87)	(1.04)	(1.16)	(0.79)	(0.90)
# obs.	162	162	189	189	189	189	162	162
log likelihood	–481.95	–477.98	–558.75	–557.11	–625.75	–622.91	–410.31	–407.77

References

Gächter, S., Renner, E., and Sefton, M. (2008). The long-run benefits of punishment. *Science*, 322:1510.