

Voting on Punishment Systems within a Heterogeneous Group

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Abstract

We consider a voluntary contributions game, in which players may punish others after contributions are made and observed. The productivity of contributions, as captured in the marginal-per-capita return, differs among individuals, so that there are two types: high and low productivity. Every two or eight periods, depending on the treatment, individuals vote on a punishment regime, in which certain individuals are permitted, but not required, to have punishment directed toward them. The punishment system can condition on type and contribution history. The results indicate that the most effective regime, in terms of contributions and earnings, is one that allows punishment of low contributors only, regardless of productivity. Nevertheless, only a minority of sessions converge to this system, indicating a tendency for the voting process to lead to suboptimal institutional choice.

JEL Code: C92, D74, H41.

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1. Introduction

When a group or a society faces a social dilemma, a potential role for an institution to promote or enforce a cooperative norm arises. If such an institutional structure is not imposed exogenously, it must arise endogenously from a social choice process involving the affected individuals. In a situation in which individuals are symmetric and their incentives to cooperate are perfectly aligned, one might argue that agreeing on a mechanism to enforce collective action might be relatively simple. The mechanism can require the individuals concerned to sacrifice an equal amount, all individuals can be punished similarly when deviating from appropriate behavior, and all individuals behaving appropriately can benefit equally.

On the other hand, suppose that players are heterogeneous. Then it is possible that the task of endogenously choosing an appropriate system to promote cooperation may be more difficult, and suboptimal institutions might emerge from the process. In this paper, we consider the effect that one type of heterogeneity among agents has on the institutions that emerge from a voting process. We employ an experimental approach. Our research strategy is the following. We take a setting, in which it is known from previous experimental results that effective institutions emerge from a simple voting process when individuals are symmetric. We then construct an experimental environment that is identical, except for the fact that there are two types of individual that differ only in the externality generated from their contributions, and introduce an analogous voting process. We find that in the heterogeneous environment, poor institutions often emerge.

The environment that we consider is a version of a popular experimental paradigm to investigate social dilemmas, the voluntary contributions mechanism for public good provision. This is a game, in which players simultaneously choose a fraction of their endowment to contribute toward the provision of a public good. The level of contribution can be readily interpreted as a measure of cooperation. While total group payoff is increasing in the sum of members' contributions, and the social optimum is reached only when all individuals contribute all of their endowment, the dominant strategy for each player is to contribute zero. One focus has been on the role of decentralized sanctions, the ability of individuals to punish others based on their level of cooperation (Yamagishi, 1986; Ostrom et al., 1992; Fehr and Gächter, 2000, 2002; Masclet et al., 2003; Sefton et al., 2007). Such sanctions have been shown to be effective in increasing cooperation¹, but to have mixed effects on welfare (Bochet et al., 2006; Tan, 2008).

¹ Two of the limitations that apply to this result are the following. The first is that, as soon as counterpunishment is allowed, some of the beneficial effect is negated (Denant-Boemont et al., 2007; Nikiforakis, 2008). The second is that there is some tendency to punish cooperative players. This tendency has been termed anti-social or perverse punishment (Cinyabuguma et al., 2006), and the incidence of this behavior varies greatly depending on population studied (Herrmann et al, 2008).

In the studies listed above, the experimenter imposed the sanctioning institution exogenously. There has been recent interest in endogenous punishment institutions that the affected individuals select themselves. Gülerk et al. (2005, 2006) permit individual players to choose, at the beginning of each period, between membership in a group with, and one without, sanctioning opportunities. They find that, while the majority of players opt for the sanction-free institution in the initial periods, the entire population eventually migrates to the group in which sanctioning is permitted. Botelho et al. (2005) construct a 21-period game in which players can vote, by majority rule, whether to allow for punishment in the last period after experiencing both systems with and without sanctioning possibilities for ten periods each. They find a tendency for groups to vote for the system that yielded them a higher payoff previously. In their study, this was typically an institution that allowed no punishment. Sutter et al. (2006) let players decide whether to impose a punishment or reward regime at the beginning of a session, by unanimity, and find that individuals prefer rewards, even though payoffs are higher under punishment. Decker et al. (2008) allow individuals to vote for enforcement of the maximum, median, or minimum punishment assigned to an individual, and also report a tendency to vote for the particular institution that yielded the highest payoff previously. They find that the maximum rule is the most effective in generating high contributions. A number of studies find that contribution rates under mechanisms enacted endogenously by group members are higher than when the same institutions are imposed exogenously (Tyran and Feld, 2004; Kosfeld et al., 2008; Bó et al, 2007).²

Ertan et al. (2009) is the study most closely related to ours. They study a setting, in which players vote at regular intervals, by majority, on whether to allow punishment of group members who have made contributions that are (a) below-average, (b) above-average, and (c) exactly equal to the average for the group. If a punishment rule is passed, any group member may assign punishment to any individual meeting the criterion of the rule. The rules are not mutually exclusive: any, none, or all of punishment options (a) – (c) could be approved. They observe that most groups, while initially choosing not to allow any punishment at all, eventually vote to allow punishment of below-average contributors exclusively. A minority of groups ban any form of punishment throughout their interaction, and no groups ever vote to allow punishment of above-average contributors. Since both contributions and earnings are highest when individuals can be punished if and only if they contribute less than the group average, the authors conclude that groups successfully converge to the most

² Two recent studies have the feature that the punishment institution voted into place only governs players who vote in favor of it. In Kroll et al. (2007), agents first play a voluntary contributions game for ten periods, and make and vote on non-binding proposals of minimum total contributions. They report that voting is an empty commitment unless punishment is used to enforce the outcome. Kosfeld et al. (2008) have a similar finding that as long as there is no provision of a binding commitment, cooperation itself is difficult to attain.

efficient institutional structure. The focus of our study here is to consider whether this ability of a voting process to converge to the optimal institutional structure is robust to a particular change in the environment. This change is the existence of heterogeneity in the value to the group of individuals' contributions.

In all of the studies mentioned above, agents were homogenous in terms of the value that their contribution generated for the group, so that the tradeoff between the social benefit of cooperation and the private benefit of free riding was identical for each member of the group. In many situations, however, heterogeneity among group members may exist, due to differing productivity of their contributions. Consider, for example, a group of individuals that must complete a project for which all group members will receive equal credit. However, the effort of some group members, because of higher productivity in the required task, yields greater benefits for all than the same effort from other members. For example, one hour of work on the part of one individual may yield the same output as three hours of another individual's work. Because all group members, including the contributor, reap the benefits of an individual's effort, this heterogeneity in productivity is equivalent to a heterogeneous cost of effort among individuals, with those with higher productivity also having lower unit opportunity cost of contribution.³ Thus, the gains and costs of a contribution depend on who made the contribution. The basic incentive structure of this situation can be captured within the experimental paradigm described above if the marginal per-capita return of a contribution (MPCR) differs depending on who is making the contribution.⁴

³ Some experiments have distinguished between the private benefit to the individual making the contribution and the benefit of the contribution to other agents, calling these the internal and external returns, respectively. Palfrey and Prisbrey (1997), Brandts and Schram (2001) and Margreiter et al. (2005) vary the internal return, while holding constant the external return. In other words, contribution costs of players differ, but every group member benefits the same given a contributed token, regardless of the identity of the contributor.

⁴ There are a few prior experiments in which MPCR differs among group members. Fisher et al. (1995) conduct a voluntary contributions game in which they assign half of the group members an MPCR of 0.75 and the other half an MPCR of 0.3. By comparing the group average contributions with those of homogenous groups featuring MPCR of 0.75 and 0.3, they conclude that the subjects seem to focus only on their own MPCR: players assigned 0.75 contribute more than those with 0.3. Reuben and Riedl (2009a) study a setting in which one player has an MPCR of 1.5, and thus a dominant strategy to contribute, and the others have an MPCR of 0.5. They allow individuals to punish others after observing the contribution profile. They find that punishment is not as effective as in a control group where everyone is endowed with the same MPCR of 0.5. Fewer strong free-riders are punished, and they exhibit a weaker increase in contributions after being punished.

Margreiter et al (2005) study voting in a common pool resource game, with players with heterogeneous contribution costs. Players are asked to vote on proposals about the proportion of endowment each group member contributes, at the end of every period. If a certain proposal is selected by majority vote, it is automatically implemented in the next period. They find that compared to homogeneous groups, the number of distinct proposals is markedly larger in heterogeneous groups, but fewer agreements are reached by majority voting.

Reuben and Riedl (2009b) consider a version of the voluntary contributions game in which players' initial endowment of income, maximum permissible contribution, and benefit from provision of the public good (the return a player receives from any individual's contribution) differ, depending on the treatment. They include

In this paper, we consider whether two key results of Ertan et al (2009) apply to a setting in which heterogeneity of group members' productivity, as expressed in the marginal-per-capita return of their contributions, exists. The two results are that (1) permitting but restricting permissible punishment to below-average contributors yields the highest payoff among punishment institutions that condition on deviations from average contribution level, and (2) when engaged in repeated opportunities to vote, groups converge to this punishment institution over time. In our experiment, as in Ertan et al., individuals vote at regular intervals on whether individuals are permitted have punishment directed toward them. After a regime is selected, based on majority vote, it is in effect for that group for a fixed and known number of periods. As in the Ertan et al. study, we vary, as a treatment variable, the number of periods that the results of one vote are in effect. Studying different voting terms is a potentially important aspect of institutional design, and the effect of a punishment system could well depend on the length of time a system is locked in and not subject to change.

The parametric structure of our experimental environment follows Tan (2008). She studies a four-person voluntary contributions game with two types of agent. Two players have an MPCR of 0.9, so that each token they contribute yields 0.9 tokens to all group members, and the other two players have an MPCR of 0.3. All agents are permitted to punish any other agent in any period. Tan finds that punishment is not very effective in increasing contributions among heterogeneous agents. In groups that achieve cooperation, high MPCR players punish low MPCR players frequently for their free-riding behavior. However, when controlling for the contribution level of the recipient of punishment, high MPCR players receive more punishment than those with low MPCR.

There is reason to believe that heterogeneity of MPCR may make a difference in which institutions emerge from the voting process. The different costs of contribution among players may inhibit the establishment of a contribution norm, and create differing beliefs among agents about the appropriate level of contribution that each type should make. This may make it more difficult to achieve consensus on which punishment system to implement and may lead to a conflict between different types of agent. Such conflicts may prove sustained and durable, with adverse long-term effects on contributions and welfare. Indeed, as described in section four, the principal results we obtain are the following. We find that, consistent with Ertan et al. (2009), the most effective institution, in terms of contributions and earnings, is one that allows punishment of below-average contributors only, regardless of productivity type. However, unlike in the Ertan et al. environment,

treatments with and without punishment. As in previous studies, they find that punishment increases contributions in all of their treatments. They argue that the norm that is established differs depending on the treatment. In treatments with unequal contribution ceilings, the norm that is enforced is to contribute in proportion to one's maximum possible contribution. In treatments with unequal marginal benefits from public good provision, the enforced norm is to contribute proportionally to the ratio of the marginal benefits.

groups often fail to enact this institution, especially when the votes are held relatively frequently. Under these conditions, groups typically establish inefficient regimes, and particularly common is a system in which no punishment is permitted. No group ever votes to enable punishment of all individuals, regardless of their type or contribution level. Players are more likely to vote to allow punishment of below-average contributors and the type other than their own, and they attempt to escape from future penalty opportunities by disallowing punishment rules targeting their own type. For many groups, this behavior appears to create an insurmountable roadblock to the establishment of the appropriate institution.

The remainder of the paper is organized as follows. In Section 2, we describe the experiment and in Section 3, we advance several hypotheses about the performance of different punishment regimes. In Section 4, we present an analysis of the data. Finally, in Section 5, we make some concluding remarks.

2. The Experiment

2.1 General Setting

The experiment consisted of six sessions that were conducted at CentER Lab, at Tilburg University in the Netherlands. There were two treatments, the *Short-Term* and the *Long-Term* treatments. Each treatment was in effect in three of the sessions. Forty-eight subjects, among whom 42% were females, and all of whom were students at Tilburg University, participated in the study. Some of the subjects had previously participated in economic experiments, but all were inexperienced with the voluntary contributions mechanism. Each subject took part in only one session of the study. On average, a session lasted about 80 minutes (including initial instruction and payment of the subjects), and a subject earned an average of 454 tokens (approximately 18.16 euros). The experiment was programmed and conducted with the z-Tree software (Fischbacher, 2007).

Each session included eight participants that were separated into two groups of four. At the start of each session, the computer program randomly assigned the subjects into different groups according to their choices of terminal upon entering the room for the session. All individuals remained in the same group for their entire 30-period experimental session. All 30 periods of play counted toward final earnings, and there were no practice periods at the beginning of the sessions. At the beginning of each period, every player was randomly given an identification number from 1 to 4 to distinguish her actions from those of the others during that period. To prevent the formation of individual reputations, however, the numbers were randomly reallocated at the beginning of every period.

Productivity heterogeneity was generated by randomly assigning half of the group members a high MPCR of 0.9 (players of this type will be referred to as type A players) and the other half a low

MPCR of 0.3 (type B players). Participants were informed of their type at the beginning of the session, and their types remained fixed for the duration of the session.⁵ The instructions used in the experiment were modified on the basis of those used in Ertan et al. (2009) and Tan (2008).⁶

2.2 Timing

The 30 periods that made up each session were divided into three segments, as illustrated in figure 1. In the first segment, comprising periods 1 – 3, subjects played the voluntary contributions game without the possibility of punishment. In the second segment, consisting of periods 4 – 6, a second stage was added to the game in which any player could punish any other player, after observing all players' contributions. In the third segment, which made up the remainder of the session (periods 7 -30), the punishment system in place depended on the outcome of a voting process. Voting took place every two periods in the Short-Term treatment, and every eight periods in the Long-Term treatment.

In each period of the first segment, the following occurred. Each subject was endowed with ten tokens, with a conversion rate of 25 tokens = 1 Euro. Subjects simultaneously and independently divided their endowment between a private account and a group account. The income of an individual equaled the number of tokens she put in her private account, plus .9 times the total contributions of type A players in her group, plus .3 times the total contribution of type B players in her group. That is, a player's income in each period equaled

$$(1) \quad I_{ij} = 10 - C_{ij} + 0.9 \times \sum_{j=A} C_A + 0.3 \times \sum_{j=B} C_B$$

where C_{ij} is the contribution of the i th player of type j . This calculation was displayed on subject i 's computer screen together with the contributions and earnings of all group members at the end of each period.

In period 4 – 6, each period was made up of two stages. There was a second, punishment, stage subsequent to the contribution stage described above. In the second stage, subjects were given the opportunity to send points ranging from 0 to 10 to any group member. Every point that a particular subject sent to another reduced the sender's earnings by one token and reduced the earnings of the recipient by two tokens. Thus, subject i 's income in each period equaled:

$$(2) \quad I_{ij} = 10 - C_{ij} + 0.9 \times \sum_{j=A} C_A + 0.3 \times \sum_{j=B} C_B - \sum_{k \neq i} P_{ik} - 2 \times \sum_{k \neq i} P_{ki}$$

⁵ Neutral language was used in the experiment. Players with MPCR of 0.9 were referred to as "type A" and players with MPCR of 0.3 were "type B". Moreover, potentially biased terms such as "contribution" and "punishment" were avoided. For example, punishment was termed as "points that reduce another player's income".

⁶ Due to page limit, the instruction is not included in this version. However, it is available online via the following link: http://center.uvt.nl/phd_stud/tan/research/.

Where $\sum_{k \neq i} P_{ik}$ was the sum of points subject i sent to all group members, and $\sum_{k \neq i} P_{ki}$ was the sum of points she received from all others. At the end of each period, the computer displayed the subject's own type, the tokens she and all group members contributed, the total number of points she received and assigned to others, her income for the current period and how it was calculated. Subjects were not informed about how much punishment other individuals sent or received.

In the third segment of each session, periods 7 – 30, the following took place. Every two periods in the Short-Term treatment, as well as every eight periods in the Long-Term treatment, a voting stage occurred at the beginning of a period. During the voting stage, every subject was required to answer each of the following four questions by clicking a box that corresponded to either (a) yes, (b) no, or (c) no preference.⁷ The four questions were the following:

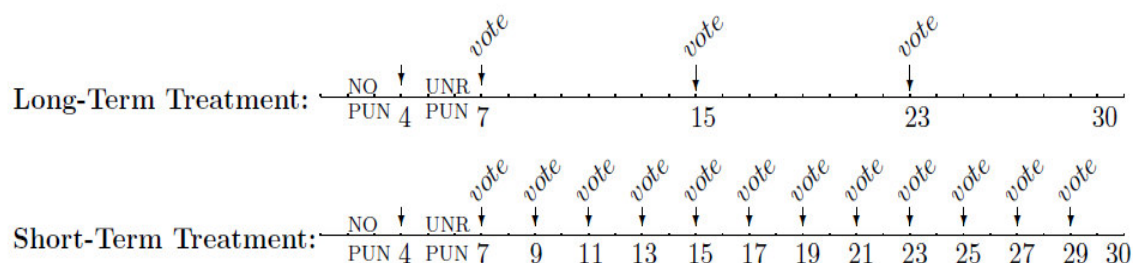
I vote to allow a person's earnings to be reduced if the person is a:

- (1) Type A player assigning less than the average amount to group account.
- (2) Type A player assigning more than the average amount to group account.
- (3) Type B player assigning less than the average amount to group account.
- (4) Type B player assigning more than the average amount to group account.

After all subjects gave their answers, the computer tabulated the votes. If the number of "Yes" votes on one of the questions exceeded the number of "No" votes, the reduction specified in the question was allowed; otherwise it was not. A "No preference" vote did not count towards the voting outcome. Since there were four questions, the number of possible outcomes, or punishment institutions, was $2^4 = 16$. Subjects were informed of the punishment system instituted, and the number of periods this institution would be in effect. In the Long-Term treatment, a vote occurred every eight periods, and the same institution remained in effect for the eight-period interval following the vote. In the Short-Term treatment, a vote took place every two periods, and the resulting system was in effect for the two periods.

⁷ Ertan et al. (2005) also included an option to vote to allow punishment of those players whose contributions were exactly equal to the average. This option is not included in this experiment, however, because if two more questions concerning average contributors of each type are included, the potential number of punishment systems would increase to 64.

Figure 1: Timing of Activity in Each Treatment



In every period, regardless of whether a vote occurred in the current period, the contribution and punishment stages occurred in a similar manner as in the second segment. During the punishment stage, subjects decided how many points to send to members meeting the punishment requirement, but were required by the computer program to abide by the restrictions resulting from the last vote, whether it occurred in the current or in a prior period. The feedback presented to subjects at the end of a period in the third segment was the same as in the second segment.

2.3 The Experiment of Tan (2008)

Tan (2008), in a related study, examines the effect of an exogenously imposed punishment institution on players with heterogeneous productivity. A number of features of that study are similar to the one reported here. The parametric structure of the game is the same in the two studies. Players played the voluntary contributions game under a fixed matching protocol, with two high productivity players with an MPCR of 0.9, and two low productivity players with an MPCR of 0.3. In one treatment, no punishment was possible, as in periods 1 – 3 in the study reported here. In another treatment punishment of any other player was permitted, as in periods 4 – 6 here.

However, there are important differences between the two studies. In the Tan (2008) study, the punishment system is imposed exogenously rather than enacted endogenously by participants themselves. Furthermore, in the Tan experiment, the length of a session is 15 periods, and the same punishment condition remained in effect for the entire session. While it is not the principal purpose of the study reported here, the similar parametric structure between our experiment and Tan (2008) allows us to make rough comparisons between the two studies, and we do so with regard to aspects of individual behavior in section 4.

3. Hypotheses

Our analysis is organized as a test of several hypotheses. The first two concern whether particular results obtained in Ertan et al. (2009) generalize to our environment. The first hypothesis is that the most effective system for promoting high welfare is to permit punishment of only below-average contributors, regardless of their productivity, a system we refer to hereafter as *Pun-Low*. The rationale for the hypothesis is that such a system enables the group to punish low contributors to influence their behavior, and prohibits punishment of high contributors in order to encourage them to continue their behavior. *Pun-low* was the most effective of all of the available systems in Ertan et al.'s (2009) environment.

Hypothesis 1 (Efficient Punishment Regime Hypothesis): *The most efficient punishment regime, in the sense of yielding the highest welfare, is to allow punishment of below-average contributors only, regardless of productivity (Pun-Low).*

Ertan et al. observed that *Pun-Low* was reached consistently after several iterations of the voting process. We consider whether this finding carries over to our setting with heterogeneous agents. While there is a powerful collective incentive to converge to the most efficient arrangement, there is also reason to believe that it may not do so in an environment with heterogeneous agents. The work of Margreiter et al. (2005) indicates that voting does not guarantee that an institution with high contributions and welfare emerges when contribution costs vary among group members. More generally, heterogeneity in MPCR leads to lower contributions (Fisher et al. 1995) even in settings in which punishment is possible (Tan, 2008), and this difficulty in cooperating may carry over to the institution formation phase. Nonetheless, as a null hypothesis we propose that the voting process will behave effectively in discovering the most efficient arrangement:

Hypothesis 2 (Punishment Regime Convergence Hypothesis): *Convergence to the most efficient rule occurs over the course of the voting process.*

Note that either Hypotheses 1 or 2 may be supported while the other one is not supported. *Pun-Low* may lead to the greatest level of welfare, but may not be attained with the voting process. An institution other than *Pun-Low* may generate the highest welfare and also be the outcome of the voting process. The next hypothesis concerns the difference between treatments. A priori, the effect of lengthening the time that an institution is in effect on per-period welfare is ambiguous. On one hand, longer governance duration implies a greater commitment to the results of a given vote, and

that may create greater incentives to form more effective institutions. On the other hand, the shorter governance duration in the Short-Term treatment offers groups more opportunities to search for effective institutions, and to discard ineffective ones, than does the Long-Term treatment. Since these two effects operate in different directions⁸, we hypothesize that the contributions made and the welfare attained are not different between the Short-Term and the Long-Term treatments.

Hypothesis 3 (Governance Duration Hypothesis): *Contributions and welfare are not significantly different between the Short-Term and the Long-Term treatments.*

4. Results

The first hypothesis concerns the relative performance of different institutional structures in terms of contributions and welfare. Table 1 displays the average group contributions and earnings under each institution across treatments. The table shows how many times each punishment system was enacted, how many periods it was in effect, the average contribution and welfare level (measured as subject earnings) it generated, and its rank among the systems in terms of contribution and welfare levels. Nine out of 16 possible combinations of punishment rules are enacted at least once in our dataset. The four most common combinations are: (1) to disallow punishment of any agent (which we will refer to as *No-Pun*), (2) to allow punishment of below-average contributors regardless of productivity (*Pun-Low*), (3) to allow punishment of Type B players making below-average contributions (*Pun-B-Low*) and (4) to allow punishment of Type A players making below-average contributions (*Pun-A-Low*). These four structures account for almost 90% of the total voting outcomes. No group ever votes to permit punishment of all agents. Result 1 summarizes the main findings concerning the relative performance of the institutions with regard to contributions and efficiency.

RESULT 1: The efficient punishment regime hypothesis (Hypothesis 1) is supported. The most effective regime, in terms of both contributions and earnings, is *Pun-Low*, which allows punishment of players with below-average contributions only, regardless of productivity. This is the case in both the Short-Term and Long-Term treatments.

SUPPORT: According to table 1, the four most successful institutions all allow punishment of at least some below-average contributors. *Pun-Low* is the most effective institution in terms of contributions

⁸ Ertan et al. (2005) also vary the length of time the results of a vote are in force, but do not discuss the effect of governance duration on outcomes.

in both treatments, and in terms of welfare in the Short-Term treatment. In the Long-term treatment, *Pun-Low* is the second-ranked system of welfare after *Pun-A-Low*. Overall, in *Pun-Low*, the mean contribution level is almost three quarters of the total endowment, which is 73% more than the next best system, *Pun-A-Low*. A Mann-Whitney rank-sum test, using average contributions in each session for the periods that the system is in effect as the unit of observation, indicates that contributions in *Pun-Low* are significantly greater than in *Pun-A-Low* ($z = -2.364$, $p < 0.05$) and than in *Pun-B-Low* ($z = -2.030$, $p < 0.05$). A similar result holds for welfare. Although welfare is not significantly greater in *Pun-Low* compared to *Pun-A-Low* ($z = -0.447$), it is significantly greater than under *Pun-B-Low* ($z = -2.030$, $p < 0.05$). □

Table 1: Frequency and Average Outcomes of Different Punishment Systems

	Long- Term Treatment					
	Number of Times Enacted	Number of Periods in Effect	Contribution rank	Average Contributions	Welfare rank	Average Welfare
Pun-Low	8	64	1	6.94	2	18.15
Pun-A-Low	4	32	2	4.13	1	20.22
Pun-B-Low	1	8	4	0.91	5	10.43
No-Pun	3	24	5	0.22	4	10.29
PunAL&PunBH	1	8	3	2.34	3	12.98
PunAH&PunBL	1	8	6	0.28	6	9.66
Pun-B-High	--	--	--	--	--	--
Pun-A-High	--	--	--	--	--	--
Pun-B	--	--	--	--	--	--
Total	18	144				
	Short- Term Treatment					
	Number of Times Enacted	Number of Periods in Effect	Contribution rank	Average Contributions	Welfare rank	Average Welfare
Pun-Low	12	24	1	8.20	1	20.67
Pun-A-Low	9	18	3	3.97	4	13.27
Pun-B-Low	18	36	2	4.57	2	15.21
No-Pun	25	50	7	0.41	7	10.50
PunAL&PunBH	2	4	5	2.88	3	14.40
PunAH&PunBL	1	2	4	3.63	6	11.03
Pun-B-High	1	2	9	0.00	9	10.0
Pun-A-High	3	6	6	2.00	5	12.3
Pun-B	1	2	8	0.13	8	10.03
Total	72	144				

There are a number of other interesting patterns evident in the table. *No-Pun* is considerably less effective in generating contributions and earnings than the systems that allow punishment of below-average contributors. There are also some differences in the incidence and relative performance of the institutions between treatments. Institutions permitting punishment of only above-average but not below-average contributors appear only in the Short-Term treatment. The inefficient *No-Pun* institution is in effect in more than twice as many periods in the Short-Term treatment than in the Long-Term treatment. The *Pun-A-Low* institution is more effective in the Long-Term treatment than in the Short-Term treatment both in terms of contribution and earnings, while the opposite holds for *Pun-B-Low*.

Table 2. Average Group Contributions and Earnings as a Function of Punishment System in Effect

Dependent variable: Group average contributions in period t , \bar{C}_i and group average earnings \bar{I}_i in period t .

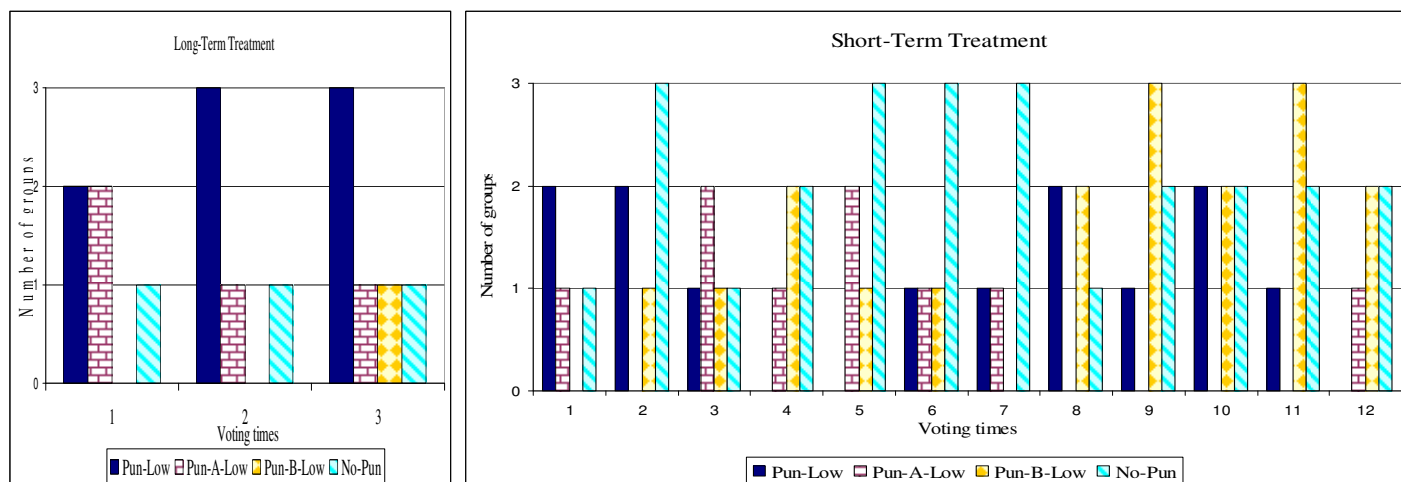
	Average Contributions		Average Earnings	
	Long-Term Treatment	Short-Term Treatment	Long-Term Treatment	Short-Term Treatment
β_1 Unrestricted Punishment	0.306 (0.578)	0.657 (0.492)	-4.979*** (1.127)	-9.434*** (2.486)
β_2 Pun Low Contributors	2.733*** (0.497)	2.989*** (0.502)	1.978** (0.969)	5.351** (2.317)
β_3 Punish A Low Contributors	-1.780*** (0.626)	-0.535 (0.507)	-1.669 (1.220)	-1.448 (2.486)
β_4 Punish B Low Contributors	-0.875 (0.826)	1.030** (0.451)	-2.295 (1.615)	0.496 (2.134)
β_5 No Punishment	-1.934** (0.843)	-1.971*** (0.417)	-2.921* (1.642)	-4.217** (2.025)
β_0 Constant	4.062*** (0.411)	3.459*** (0.339)	16.704*** (0.801)	14.718*** (1.171)
Adjusted R squared	0.353	0.399	0.273	0.459
Observations	164	166	164	166

Notes: *10% significance; **5% significance, ***1% significance. Contribution data corresponding to infrequently enacted institutions such as *PunAL&PunBH*, *PunAH&PunBL*, *PunAH*, *PunBH* and *PunB* are excluded because of the insufficient number of observations. The model specification is a fixed effect model with the variable “group” as the individual effect. The standard errors are robust within group correlation. A Chow test rejects the null hypothesis that the coefficients of Long-Term and Short-Term treatments are equal. Therefore, we conduct a separate estimation for each treatment.

Table 2 reports the results of a regression estimating the effect of the different institutions on contribution and welfare levels. The data in the first three periods of the sessions, in which no punishment regime is in effect, are the baseline of the regressions. Unrestricted punishment, in effect in periods 4 – 6 of each session, and in which players can reduce the earnings of any other player, does not lead to higher contribution levels, but does lower earnings, in both treatments. This is indicated by the estimates for β_1 . The significantly positive β_2 across all equations confirms the robust effect of allowing for punishment of below-average contributors: this increases group average contribution levels and earnings relative to the baseline. The significantly negative coefficient β_5 indicates that if players vote out to disallow any form of punishment during the voting stage, group average contributions and earnings decrease relative to a situation in which the same system is imposed exogenously.

The second hypothesis concerned whether the most effective institutional structure emerges from the voting process. Our findings are summarized in result 2.

Figure 2: Punishment Systems Enacted, Both Treatments, By Timing of



RESULT 2: Punishment Regime Convergence Hypothesis (Hypothesis 2) is not supported. Institutional rules fail to converge to the efficient *Pun-Low* system in either treatment.

SUPPORT: Figure 2 shows the incidence of each institution in each of the sequence of votes in the two treatments. The horizontal axis of the figures represents the timing of the vote, with voting time “1” indicating the first vote in a session, which occurs at the beginning of period 7. The second vote

occurs in period 9 in the Short-Term and in period 15 in the Long-Term treatment. The vertical axis represents the number of groups, out of a total of six groups, that choose each system. None of the six groups votes for *Pun-Low* during their last vote in the Short-Term treatment, while only three of the six groups do so in the Long-Term treatment. □

As we can see from the data in the figures, the relatively efficient *Pun-Low* institution is chosen with greater frequency in the Long-Term treatment. However, the positive effect on welfare of the relatively frequent choice of *Pun-Low* in the Long-Term treatment is not sufficient to offset the even greater increase in contributions and welfare that occurs in those instances when subjects in the Short-Term treatment select *Pun-Low*. Result 3 summarizes our findings.

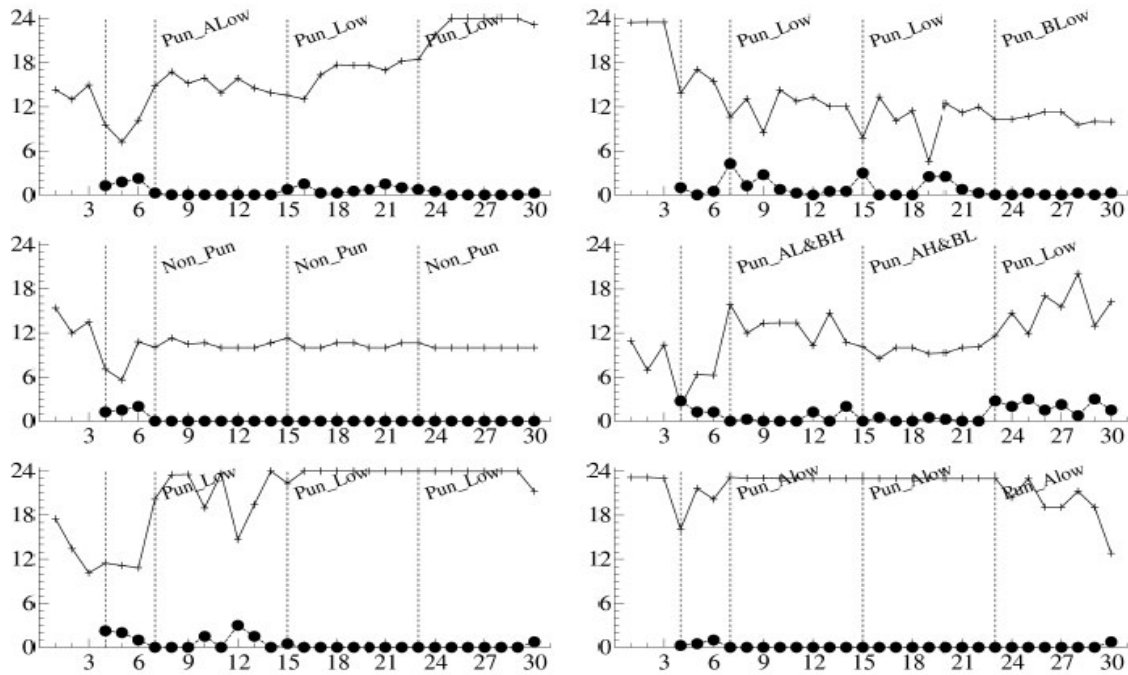
RESULT 3: The Governance Duration Hypothesis (Hypothesis 3) cannot be rejected. That is, we cannot reject the null hypothesis that the Short-Term and the Long-Term treatments generate equal contributions and equal welfare.

SUPPORT: Mann-Whitney rank sum tests of differences in contributions and welfare between the Short-Term and Long-Term treatment in periods 7 to 30, taking each group's activity over those 24 periods as a unit of observation, suggest that neither distributional difference is significant between the two treatments ($z = 0.320$ for contribution and 0.801 for earnings). □

Figures 3a and 3b show the time series of earnings and punishment points assigned for each group, in the Long-Term and Short-Term treatments, respectively. The vertical axis indicates the per-capita earnings in tokens (the maximum possible is 24, and the level corresponding to zero contribution and zero punishment is 10), and the number of punishment points allocated per capita. The horizontal axis is the period number. Both figures show that, while *Pun-Low* performs better than the other systems on average in terms of earnings, it remains inconsistent and only reaches welfare levels close to the potential maximum in some instances. It is also clear that punishment is effective in raising contributions, at least in the short run; in almost every period after which any punishment points are assigned, there is an increase in group earnings. The *No-Pun* institution consistently leads to zero or near-zero contributions, as reflected in average earnings near ten tokens. In the Long-Term treatment, three groups achieve close to the maximum possible level of earnings, and they do so by enacting *Pun-Low* or *Pun-A-Low*. In the Short-Term treatment, institutional changes are quite frequent with at least four changes, between one vote and the next, occurring in each group. Only two

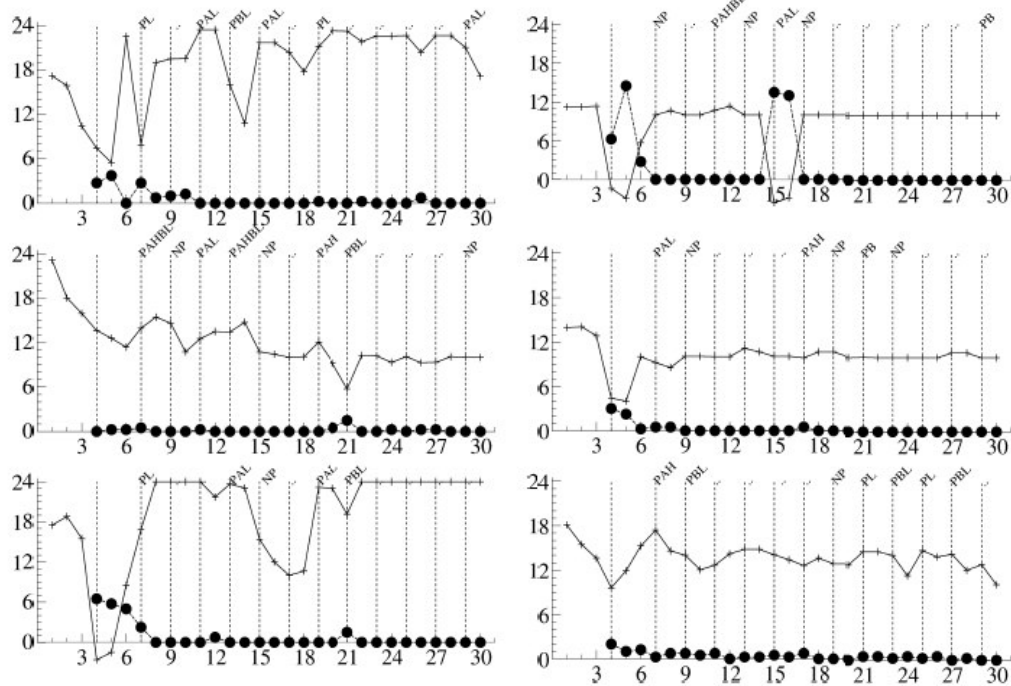
groups achieve close to maximal earnings by the end of their session. One does so by enacting *Pun-Low*, and the other with *Pun-B-Low*.

Figure 3a: Earnings and Punishment Levels in the Long-Term Treatment



Notes: Each panel corresponds to one group in the treatment. The horizontal axis designates the number of periods, with the segments indicating the periods in which a specific institution is in effect. The names of the voted institutions are written in the upper part of each segment. The lines with crosses represent the group average earnings, and the lines with dots represent average sanction points.

Figure 3b: Earnings and Punishment Levels in the Short-Term Treatment



Notes (Cont'd): *PL* is short for “allowing punishment of players with below average contributions”; *PAL* is short for “allowing punishment of type A players with below average contributions”; *PBL* is short for “allowing punishment of type B players with below average contributions”. *NP* is short for “not allowing any form of punishment”. *PB* is short for “allowing punishment of type B players. *PunAHBL* is short for “allowing punishment of type A with above average contributions”. *PAH* is short for “allowing punishment of type A players with above average contributions.

Figures 4a and 4b show the voting behavior of individuals based on their type and contribution level in the period immediately preceding the vote. Each panel in the figures corresponds to the voting behavior of one four types/contribution profiles in one of the treatments. Each bar indicates the percentage voting in favor, voting against, and abstaining from each of the four punishment rules. The figures are constructed by classifying each player into one of the four categories: type A below-average contributors (abbreviated to AL), type A above-average contributors (AH), type B below-average contributors (BL) and type B above-average contributors (BH) based on her actual contribution one period before the voting stage. Then the number of “yes”, “no” and “no preference” votes are summed.

Figure 4a: Voting Patterns in the Long-Term Treatment, Percentage of Players Voting to Punish Each Type and Contribution Level

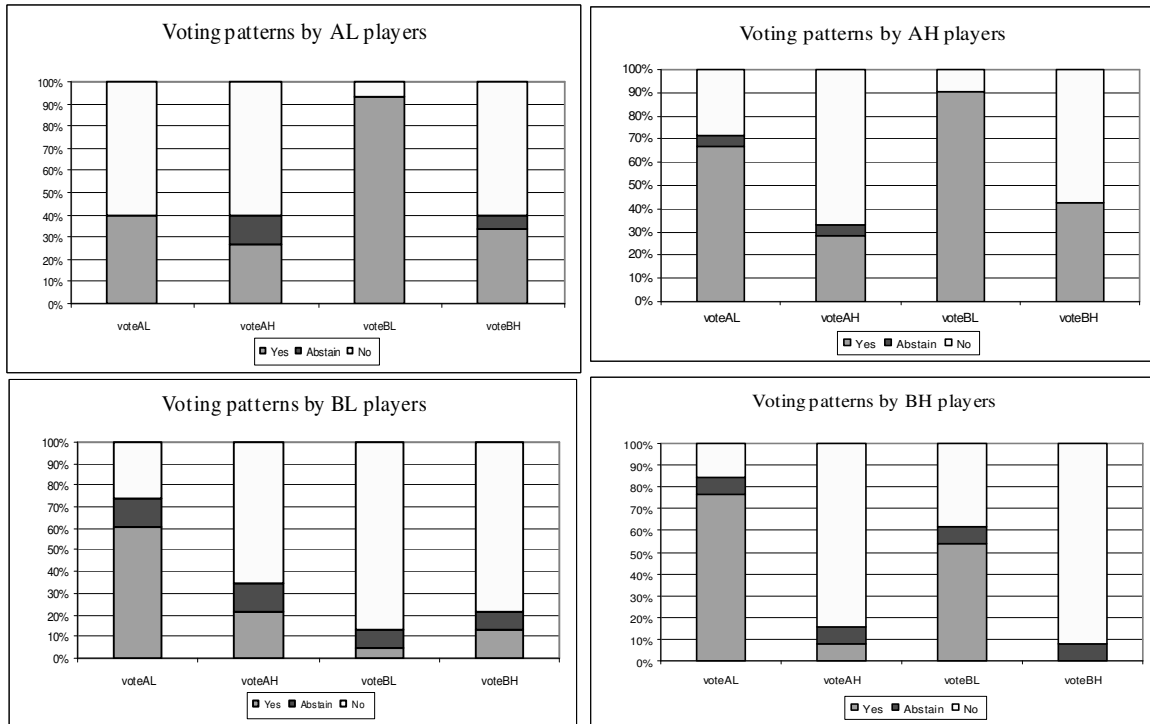
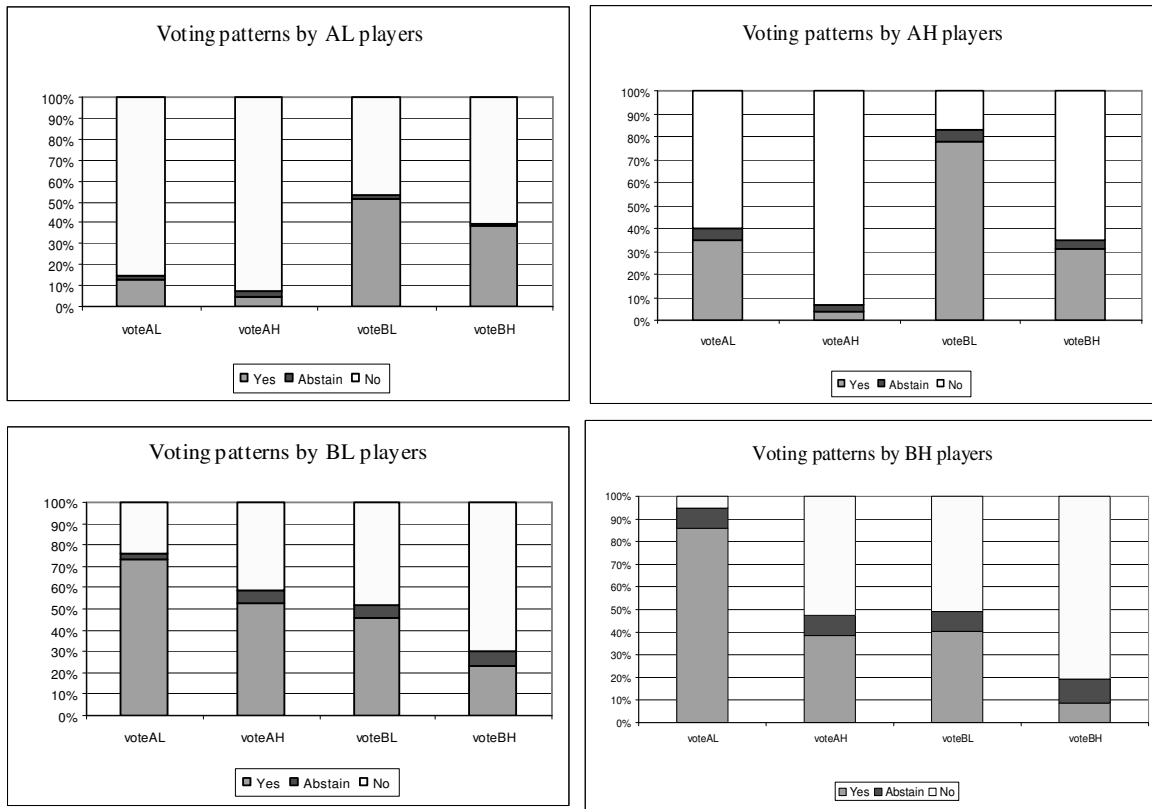


Figure 4b: Voting Patterns in the Short-Term Treatment, Percentage of Players Voting to Punish Each Type and Contribution Level



The figures illustrate the sharp conflicts between above-and below-average contributors, as well as between type A and type B players. When above-average contributors vote in favor of punishment of below-average contributors, they are much more likely to vote in favor of punishment of the other type. Likewise, when they vote against allowing punishment of above-average contributors, they are more likely to vote in favor of banning this punishment for their own type. Below-(above-) average contributors are more willing to vote to allow punishment of above-(below-) average contributors than of players who contribute similarly to themselves.⁹ These patterns suggest that players try to shut down punishment channels that may point to them in the future.

Table 3. Voting Patterns

Dependent variable: Voting of player i in favor of permitting punishment of player k at time t , \bar{V}_{ik}^t

	Long-Term Treatment	Short-Term Treatment
β_1 Yourself	-0.720* (0.397)	0.182 (0.174)
β_2 Opposite MPCR	0.917*** (0.279)	1.259*** (0.126)
β_3 Below Average Contributor	1.467*** (0.221)	0.968*** (0.093)
β_4 Type i	1.017** (0.406)	0.697*** (0.217)
β_5 Type A Player	0.208 (0.203)	-0.151* (0.091)
β_6 Opposite Contribution	0.252 (0.261)	0.526*** (0.119)
β_7 Punishment Received at Period (t-1)	-0.007 (0.073)	-0.045 (0.033)
β_8 Punishment Sent at Period (t-1)	0.051 (0.072)	0.010 (0.017)
β_0 Constant	-2.060*** (0.489)	-1.330*** (0.219)
Log-Likelihood	-123.72	-553.26
Observations	268	1098

Notes: *10% significance; **5% significance, ***1% significance. Only “yes” votes and “no” votes are included in the estimation; abstentions are excluded. A random effect probit model with observations clustered within group correlation is reported. The results of a random effect logit model and a fixed effect logit model are highly similar.

Consider the following probit regression.

$$(3) \quad V_{ik}^t = \beta_0 + \beta_1 \text{yourself} + \beta_2 \text{opp_MPCR} + \beta_3 \text{low_con} + \beta_4 \text{type}_i + \beta_5 \text{typeA} + \beta_6 \text{opp_con} + \beta_7 \text{pun_rec} + \beta_8 \text{pun_sent} + \varepsilon_{ik}^t$$

The dependent variable equals 1 if subject i votes to permit a specific punishment rule k in period t , and 0 otherwise. The first explanatory variable, *yourself*, is a dummy variable that equals 1 if the rule allows punishment of a player with the same type and similar contribution behavior as player i exhibited in period $t-1$. *Opp_MPCR* equals 1 if the voted item k refers to the other type of player, and

⁹ There is one exception. In the Long-Term treatment, AH players rather than AL players are more willing to allow for punishment of BH players: 43.5% of AH players vote to allow for punishment of BH players while only 30.8% of AL players vote to allow for punishment of BH players.

Opp_con is analogous for the opposite contribution level relative to the average. *Low_con* equals 1 if the voted item refers to someone making a below-average contribution. *Typei* is also a dummy equal to 1 if the player voting is a type A player, whereas *TypeA* equals to 1 if the voted rule targets type A players. *Pun_rec* and *Pun_sent* are continuous variables representing the total number of punishment points received from other players and sent to other players, respectively, in the period immediately preceding each vote. Result 4 summarizes the findings.

RESULT 4: (Voting Behavior) In both treatments, the willingness of players to vote on punishment of a certain player is greater (i) if the punishment rule refers to the opposite MPCR, (ii) if the rule refers to below-average contributors, and (iii) if the voter has a high MPCR.

SUPPORT: The estimates in table 3 show highly significant positive coefficients of β_2 , β_3 , and β_4 . This indicates that players are more willing to vote in favor of a punishment rule if it targets the opposite productivity type (β_2), below-average contributors (β_3), and if the player voting has a high productivity level (β_4). □

Previous research indicates that the number of punishment points one individual assigns to another is influenced by the difference in contribution between the punishing and the punished agent, as well as the difference between the negative deviations of the recipient's contribution from the group average level (Fehr and Gächter, 2000; Masclet et al., 2003; and Falk et al., 2005). Consider the following regression equation, whose estimates are given in table 4.

$$(4) \quad P_{ik}^t = \beta_0 + \beta_1 \left(\max \{0, c_i^t - c_k^t\} \right) + \beta_2 \left(\max \{0, c_k^t - c_i^t\} \right) + \beta_3 \left(\max \{0, \bar{c}^t - c_k^t\} \right) + \beta_4 \left(\max \{0, c_k^t - \bar{c}^t\} \right) + \beta_5 type_i + \beta_6 type_k + \varepsilon_{ik}^t$$

where $type_i = 1$ if the punisher i has an MPCR of 0.9; $type_k = 1$ if the punished k has an MPCR of 0.9, and \bar{c}^t is the average contribution within the group in period t . Because of the large number of zero values for the dependent variable, we estimate this specification with a Tobit model. The standard errors take into account within-group correlation.

Empirical evidence also shows that low contributors on average respond to punishment by raising their contributions in the subsequent period (Fehr and Gächter, 2000; Masclet et al, 2003). The change in the contribution of player i between period t and $t+1$ can be modeled as:

$$(5) \quad c_i^{t+1} - c_i^t = \beta_0 + \beta_1 \left(\sum_k P_{ki} \right) + \beta_2 (\bar{c}^t - c_i^t) + \beta_3 type_i + \beta_4 \left(type_i \times \sum_k P_{ki} \right) + \varepsilon_i^t$$

where $type_i = 1$ if i is a high-productivity player. β_1 measures the effect of the total number of points subject i receives on her change in contribution from one period to the next, and β_2 is the effect of the difference between individual i 's contribution and her group average contribution level in period t . β_3 measures any difference in overall contribution change between the two types, and β_4 registers a differential response to punishment on the part of high and low productivity types. The estimates of models (4) and (5), for the data from the exogenously-imposed unrestricted punishment system studied in Tan (2008), are also included in tables 4 and 5 under the column labeled *Unrestricted Punishment*. In table 5, only the observations in which an individual's contribution in period t is lower than his group's average for the period are included. Result 5 summarizes the main findings from the estimation of (4) and (5).

Table 4. Determinants of Sanctioning Behavior under *Pun-Low*Dependent Variable: Punishment points player i sends to player k at time t : P_{ik}^t

	Unrestricted punishment (source Tan(2008))	Pun-Low	
		Long- Term	Short- Term
β_0 Constant	-5.326*** (1.975)	- 3.226*** (0.630)	- 2.968*** (0.803)
β_1 Negative Deviation from i 's Own Contribution ($\max\{0, c_i - c_k\}$)	0.546** (0.259)	0.752*** (0.130)	1.769*** (0.671)
β_2 Positive Deviation from i 's Own Contribution ($\max\{0, c_k - c_i\}$)	0.078 (0.223)	1.144*** (0.423)	-- --
β_3 Negative Deviation from Average ($\max\{0, \bar{c} - c_k\}$)	0.799** (0.352)	-0.201 (0.199)	-1.346 (0.862)
β_4 Positive Deviation from Average ($\max\{0, c_k - \bar{c}\}$)	-0.162 (0.242)	-- --	-- --
β_5 Type i	-0.497 (1.096)	-0.325 (0.529)	0.431 (0.673)
β_6 Type k	0.787* (0.475)	-0.268 (0.533)	0.084 (0.669)
Log-Likelihood	-744.01	-277.957	-75.205
Observations	1080	278	99

Notes: *10% significance; **5% significance, ***1% significance. Only the observations of individuals who could potentially be punished are included. Since the earnings of above-average contributors are not allowed to be reduced, the β_4 coefficient is not included in the *Pun-Low* estimation.

Table 5. Subsequent changes in Contributions of Below-average Contributors as a Function of Punishment Received and Type

Dependent variable: changes of contribution $C_i^{t+1} - C_i^t$

	Unrestricted Punishment (source, Tan (2008))	<i>Pun-Low</i> , Short- and Long-term Treatments Pooled
β_1 Punishment Received at Period t	0.289*** (0.067)	0.185 (0.162)
β_2 Deviation from average	0.169*** (0.056)	0.512** (0.205)
β_3 Type i	0.058 (0.401)	0.314 (0.805)
β_4 Punishment Received * Type i	0.340*** (0.127)	0.304 (0.202)
β_0 Constant	0.891*** (0.258)	-0.886 (0.603)
Adjusted R squared	0.250	0.324
Observations	161	66

Notes: *10% significance; **5% significance, ***1% significance. The model specification procedure is as follows. Firstly, for *Pun-Low* institution, a Chow-breaking point test cannot reject the null hypothesis that the contribution responses of the Long-Term treatment and Short-Term treatment are the statistically equivalent ($F(3, 58) = 0.93, p=0.432$). Therefore we only report one result by combining two treatments together. We then compare a pooled OLS with robust standard errors; a fixed effect model and a random effect model. The pooled OLS proves to be the best specification through a Language-Multiplier test comparing with the random effect model and an F-test with a fixed effect model. For the unrestricted punishment institution (source Tan (2008)), we run the same regression on players who contribute less than average at period t.

RESULT 5: (Punishment Behavior and Responses) Under *Pun-Low*, the level of monetary sanction is increasing in the negative difference between the contributions of the recipient and the punisher in both treatments. Players increase their contributions more in the subsequent period, the farther their contribution is below the group average. The two types of player respond similarly to the receipt of punishment.

SUPPORT: The estimates in table 4 show that in both *Pun-Low* and the unrestricted punishment regime, there is a positive relation between the punishment points player i sends to player k and the extent to which player k 's contribution below that of player i 's. Unlike under unrestricted punishment, there is no relationship between the type of either the sanctioner or the sanctioned party in terms of punishment behavior. Table 5 indicates that in the *Pun-Low* regime, the contribution level increases significantly, the more a player's contribution is below group average (β_2). The insignificance of the β_1 coefficient suggests that it is not the actual sanction that, but rather the possibility of punishment, which triggers increases in contribution when punishment of below-average contributors is enabled. The significant β_4 coefficient in the Unrestricted Punishment data indicates that type A players are more likely to increase their contribution in response to punishment than type B players. However, this difference between types is not observed under *Pun-Low*. \square

5. Conclusion

We have studied the voting behavior of groups that face a social dilemma. At regular intervals, the groups vote to select a punishment institution, a set of conditions under which individuals may punish others. The issue we investigate is whether the most efficient institution, in terms of yielding maximal gains to the group, emerges from the voting process. We pose this question for an environment in which players are heterogeneous in terms of the benefit that their contributions yield to the group.

It is clear which institutions promote high levels of contributions and welfare. These are institutions that allow punishment of low contributors. In particular, we observe that Pun-Low, which allows punishment of low contributors regardless of type, while immunizing high contributors, performs well in generating high average contributions and welfare levels. This extends a previous result obtained by Ertan et al. (2009) in a similar setting with symmetric players, to an environment with asymmetric players. When the Pun-Low system is in place, little punishment is actually applied. The threat of punishment is typically sufficient to generate high levels of cooperation at a low cost of enforcement.

However, we find that groups often fail to adopt this institution even after having repeated opportunities to vote for its enactment. The heterogeneity of players and the ability to vote to selectively punish individuals by type as well as by behavior appears to lead to negative consequences. It generates conflicts as players attempt to prevent punishment that can be directed at themselves, while attempting to enable punishment on players who differ in both contribution behavior and type. The result is that, because majority support is required to enact a punishment rule, groups often find

themselves with no ability to punish some or all free riders, and thus without a mechanism for enforcing high contributions. Furthermore, in a setting with asymmetries, this type of conflict may be exacerbated by disagreement between players of different types on the appropriate norm of contribution, and thus on the appropriate punishment rule. When a punishment rule must be enacted with a majority vote, this disagreement appears to propagate back to the time of voting, and voters seek to protect themselves from the possibility of receiving punishment that they view as inappropriate.

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