The Public Goods Game, Cooperation and Punishment

-Prisoners' dilemma and Public Goods Games

-Conditional cooperation

-Monetary punishment to enhance cooperation

-Non-monetary punishment to enhance cooperation

-Behavior in the lab and cooperation in the field

The Prisoners' Dilemma Game

Two persons simultaneously decide whether to cooperate or defect. The joint monetary payoff is maximized if both cooperate, but each individual maximize their own monetary payoff by defecting. Can also be played sequentially.

	C	D
C	50,50	5,80
D	80,5	20,20

The Public Goods Game

Each individual in a group of individuals simultaneously decide how much of an endowment to contribute to a public good. The sum of the monetary payoffs is maximized if all individuals contribute the entire endowment, but each individual maximize their own monetary payoff by contributing zero. A generalization of the Prisoners' dilemma game to more than two players and more than two choices.

Example: 4 players, $10 endowment for each player, each dollar contributed to the public good yields a payoff of 0.4 dollars for each group member (and each member gets to keep the part of the endowment not contributed to the public good).

Stylized Facts from Prisoners' dilemma and Public Goods games

The complete free-riding (defect) prediction is rejected; a substantial fraction of subjects cooperate/contribute to the public good.

The contributions (rate of cooperation) decreases over time with repetition of the game (with new partners in every new round/period; i.e. a repeated one-shot game).

Potential reasons for cooperation:

Altruism (cooperation increase payoff of other players and joint payoffs)

Fairness (multiple equilibria)

Mistakes/Random behavior (may decrease with learning)

Conditional cooperation

Conditional Cooperation in Public Goods games (Fischbacher et al Economics Letters 2001)

Design: A one-shot public goods game with four players in each group. Each individual receive an endowment of 20 tokens. Each ”token” invested in the public good yields a payoff of 0.4 tokens for each group member. The strategy method used.

Subjects make two types of contribution decisions:

”Unconditional contribution”: The subjects decides how much to contribute to the public good without knowing how much the other players in the group are contributing.

”Contribution table”: Subjects decides how much they will contribute to the public good for each of the 21 possible average contribution levels of the other group members (rounded to integers). This decision is made after the unconditional contribution decision.

Determination of payoffs: It is randomly determined which of the two contribution decisions that is used to determine payoffs. For three randomly chosen subjects in each group the unconditional contribution decision is used, and for the fourth subject in each group the Contribution table decision is used (the decision for the average contribution of the other three group members).

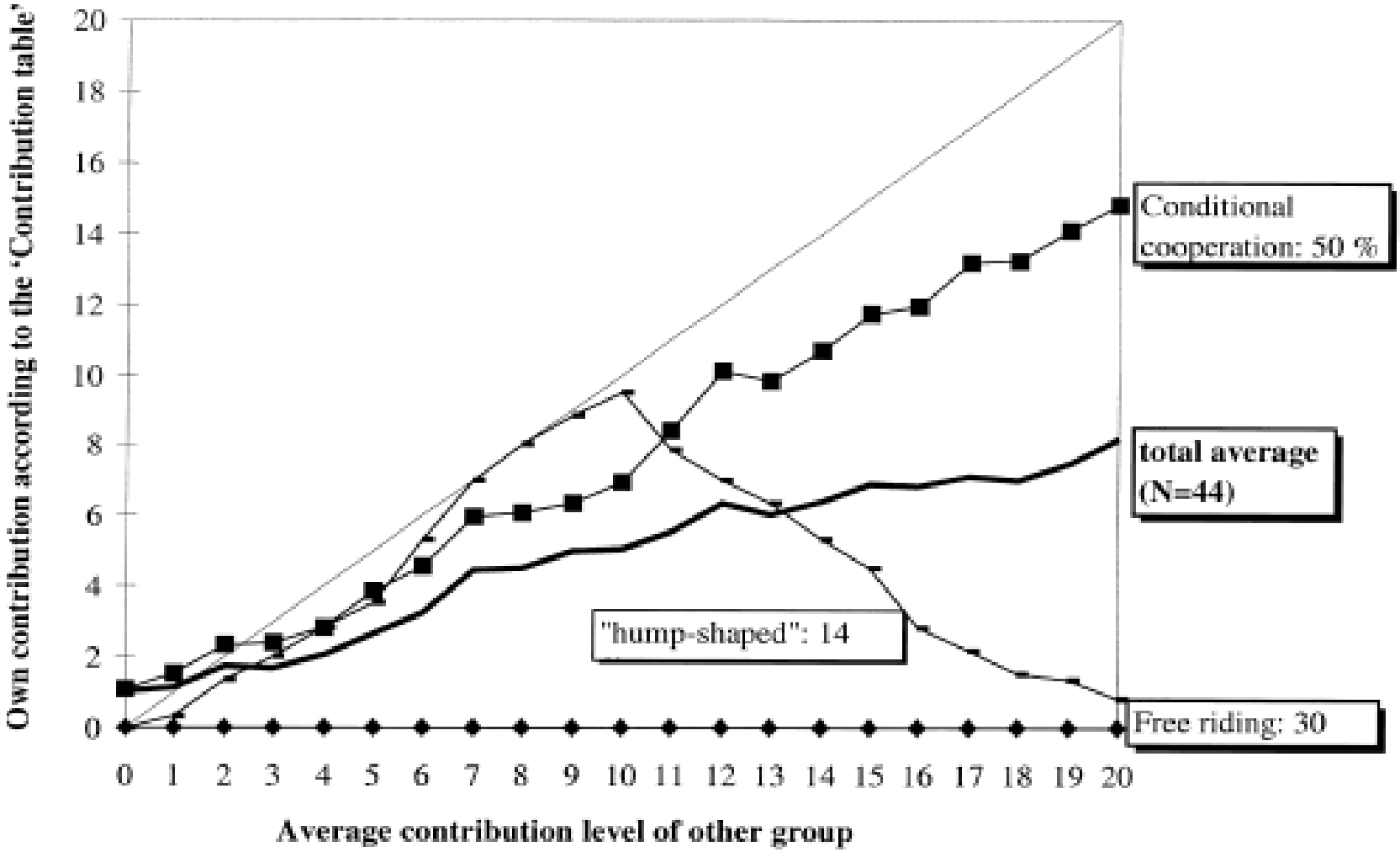


Fig. 1. Average own contribution level for each average contribution level of other members (diagonal = perfect conditional).

Public Goods game with Monetary Punishment (Fehr and Gächter AER 2000)

Design: A public goods game with four players in each group. Each individual receive an endowment of 20 tokens each period. Each ”token” invested in the public good yields a payoff of 0.4 tokens for each group member. The game is played for 20 periods.

Treatments:

Stranger-treatment with and without punishment: New random group composition in each round. Ten periods of the game without punishment and ten periods with punishment. In Sessions 1 & 2 the subjects play the 10 periods with punishment first, and in Session 3 the subjects play the 10 sessions without punishment first.

Partner treatment with and without punishment: The same group composition in each round. Ten periods of the game without punishment and ten periods with punishment. In Session 4 the subjects play the 10 periods with punishment first, and in Session 5 the subjects play the 10 sessions without punishment first.

The design involves comparisons of the effect of punishment both within and between subjects.

Cost of punishment: With punishment each subject can assign up to 10 punishment points (pp) to each other group member (after being informed about the contribution to the public good of each group member). Each punishment point assigned to an individual reduces the payoff by 10% of that individual. The cost of punishment is: 1 (1 pp), 2 (2 pp), 4 (3 pp), 6 (4 pp), 9 (5 pp), 12 (6 pp), 16 (7 pp), 20 (8 pp), 25 (9 pp), 30 (10 pp).

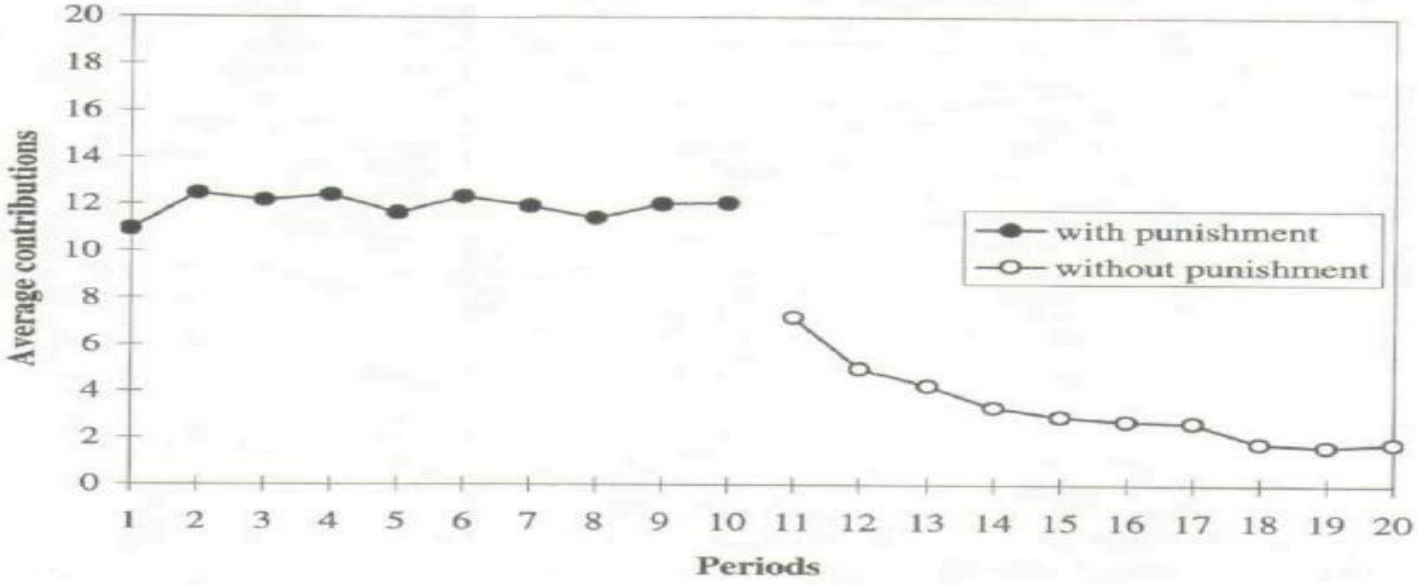


FIGURE 1A. AVERAGE CONTRIBUTIONS OVER TIME IN THE STRANGER-TREATMENT (SESSIONS 1 AND 2)

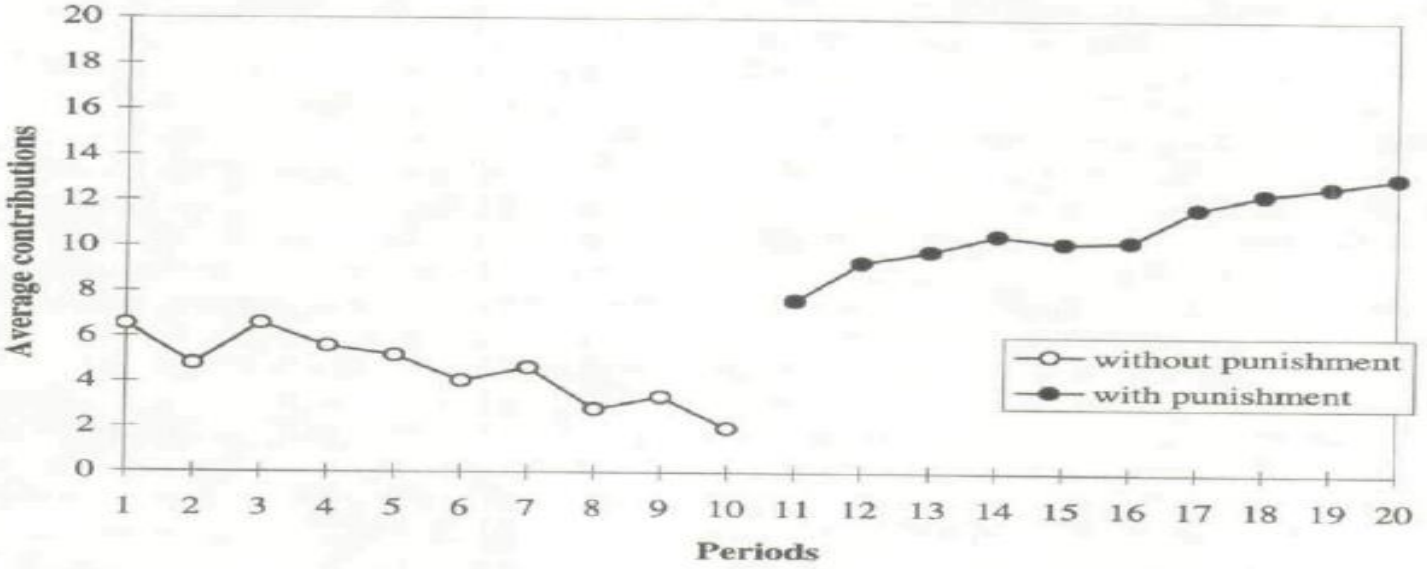


FIGURE 1B. AVERAGE CONTRIBUTIONS OVER TIME IN THE STRANGER-TREATMENT (SESSION 3)

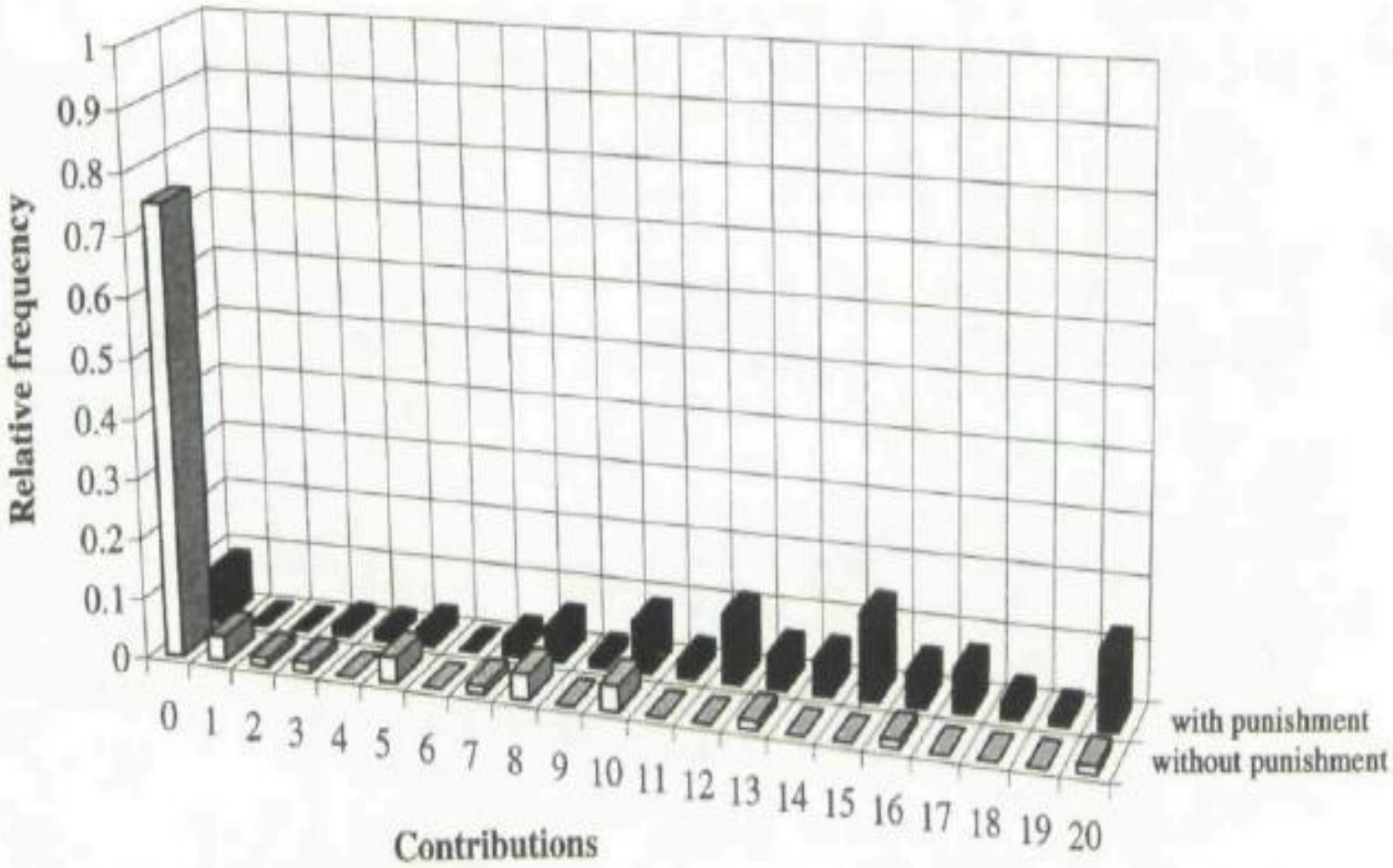


FIGURE 2. DISTRIBUTION OF CONTRIBUTIONS IN THE FINAL PERIODS OF THE STRANGER-TREATMENT WITH AND WITHOUT PUNISHMENT

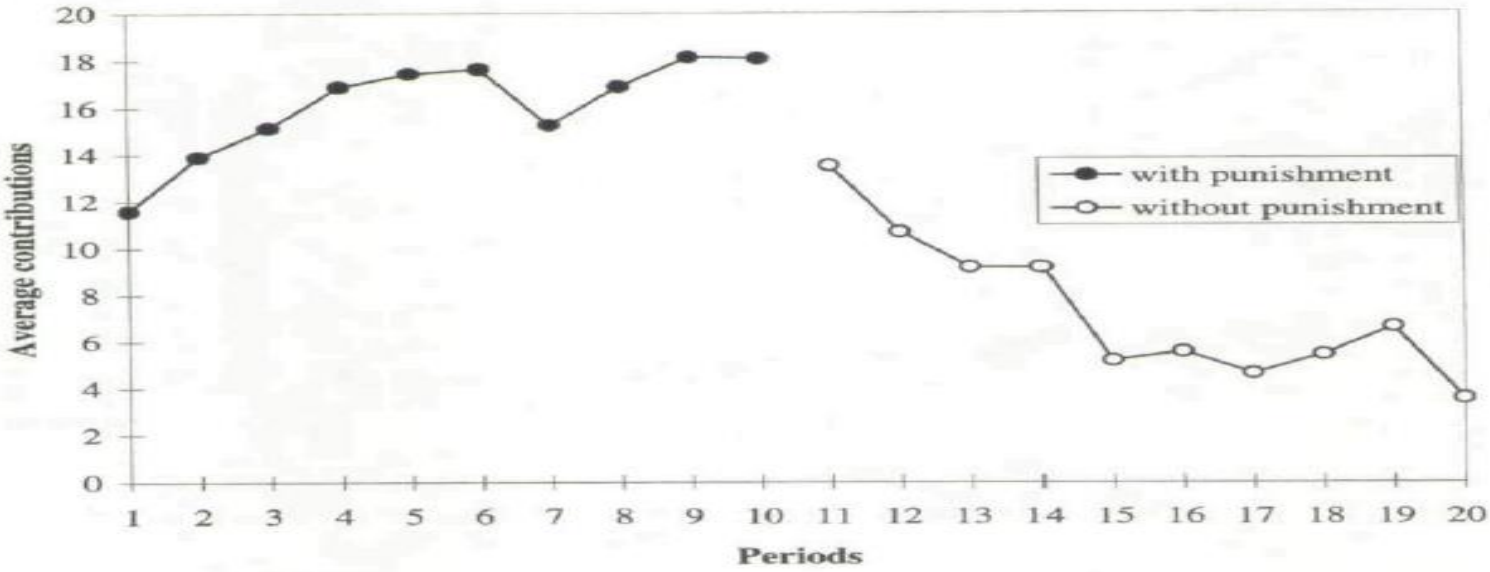


FIGURE 3A. AVERAGE CONTRIBUTIONS OVER TIME IN THE PARTNER-TREATMENT (SESSION 4)

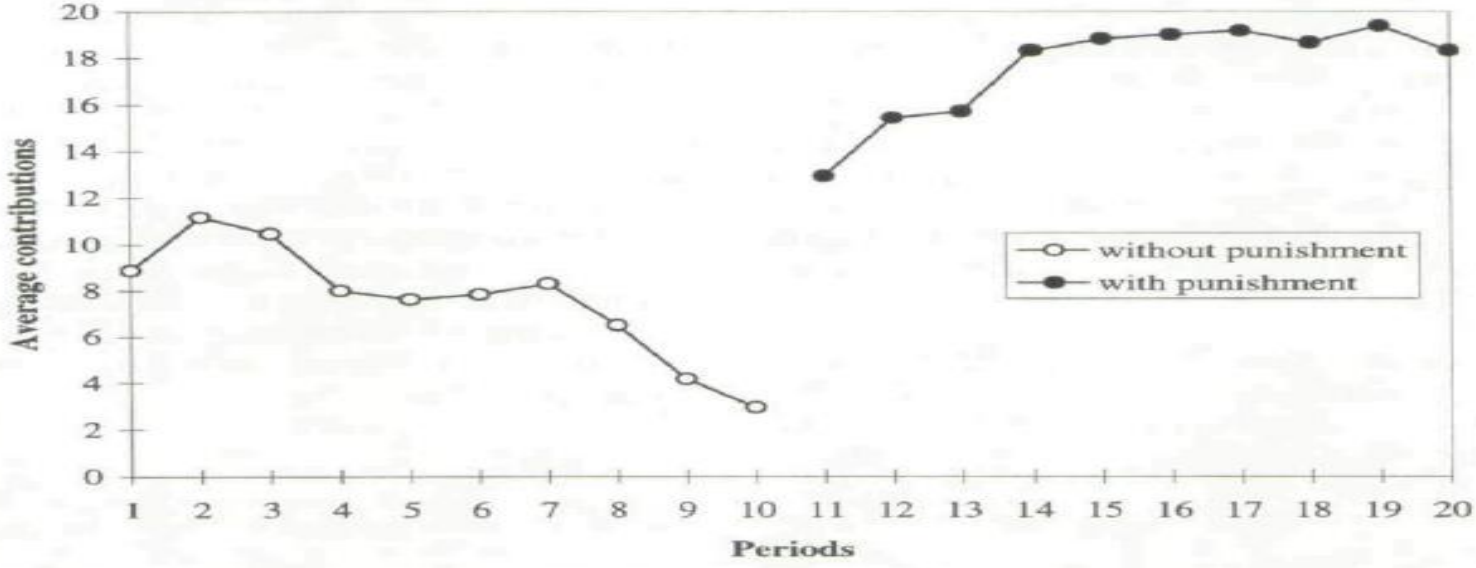


FIGURE 3B. AVERAGE CONTRIBUTIONS OVER TIME IN THE PARTNER-TREATMENT (SESSION 5)

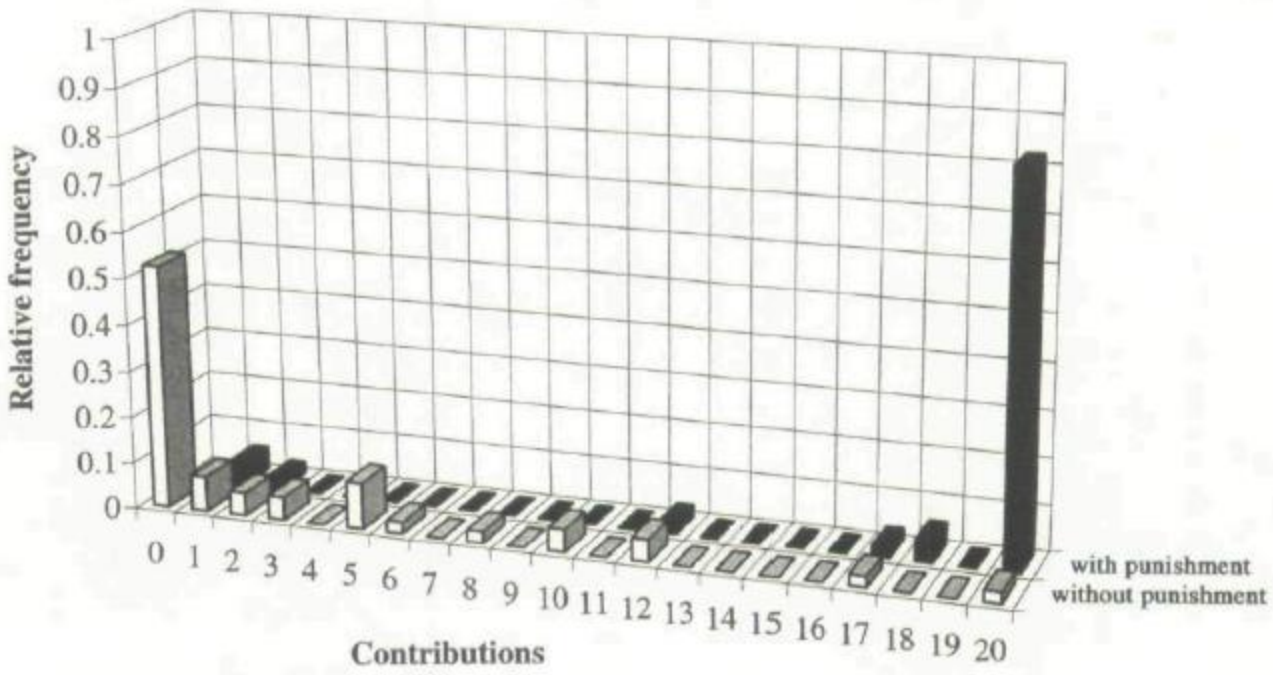


FIGURE 4. DISTRIBUTION OF CONTRIBUTIONS IN THE FINAL PERIODS OF THE PARTNER-TREATMENT WITH AND WITHOUT PUNISHMENT

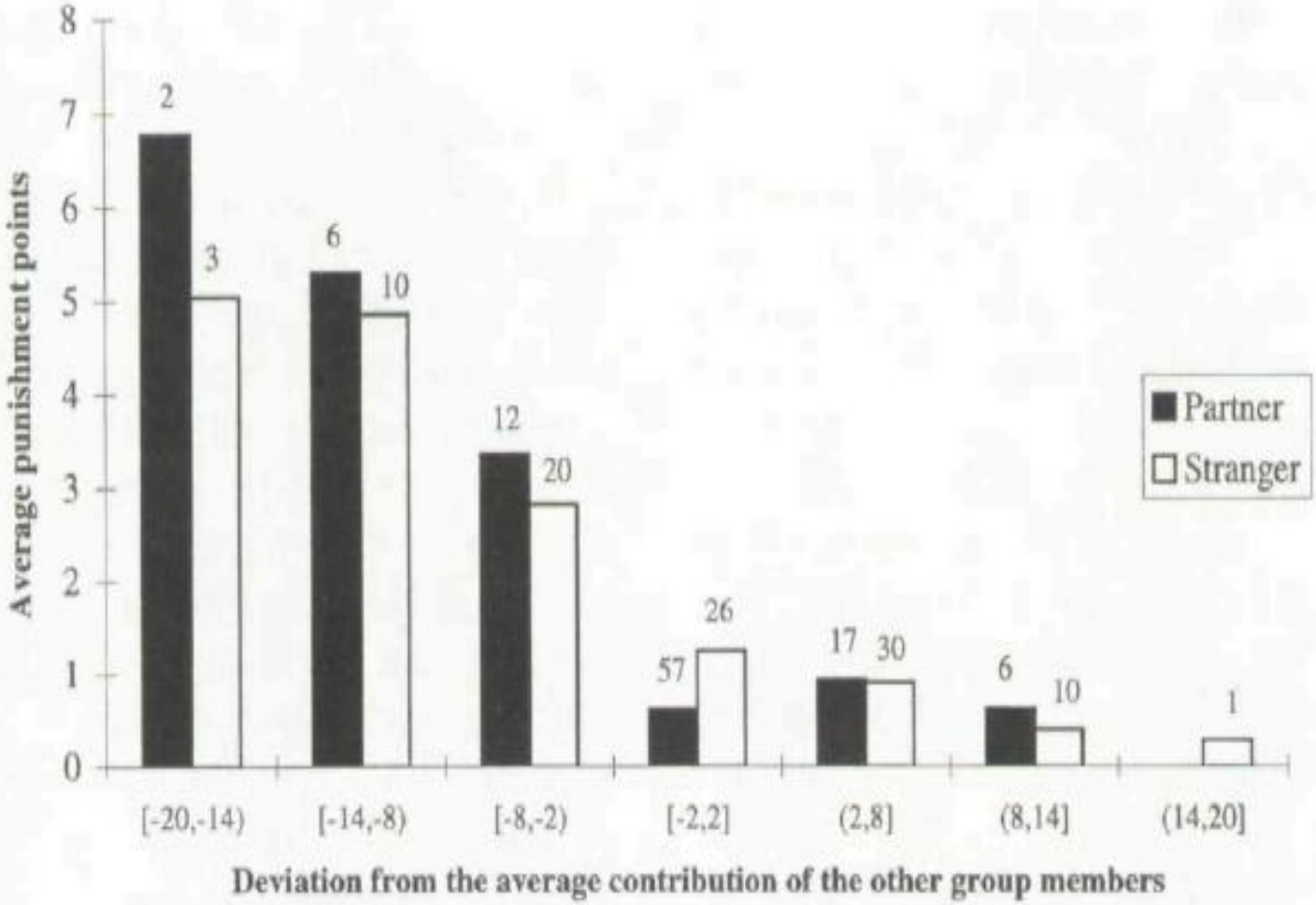


FIGURE 5. RECEIVED PUNISHMENT POINTS FOR DEVIATIONS FROM OTHERS' AVERAGE CONTRIBUTION

Public Goods game with Monetary and Nonmonetary Punishment (Masclet et al AER 2003)

Design: The same public goods game as in Fehr & Gächter (AER 2000). The game is played for 30 periods.

Treatments:

Monetary punishment (MP) treatment: Replicates the monetary punishment treatment in Fehr & Gächter (AER 2000). No punishment in periods 1-10 and periods 21-30; and punishment in period 11-20. Partner matching in all periods (the group is the same in all periods)

Non-monetary punishment (NP) treatment: Same as in the Monetary punishment treatment, but with the difference that subjects could now only communicate points as a signal of disapproval (0 points=the least disapproval; 10 points=the most disapproval); i.e. the punishment points had no payoff consequences. No punishment in periods 1-10 and periods 21-30; and punishment in period 11-20. Partner matching in all periods.

Non-monetary punishment stranger (NS) treatment: The same as the NP treatment; but with stranger matching after period 10 (partner matching the first ten periods).

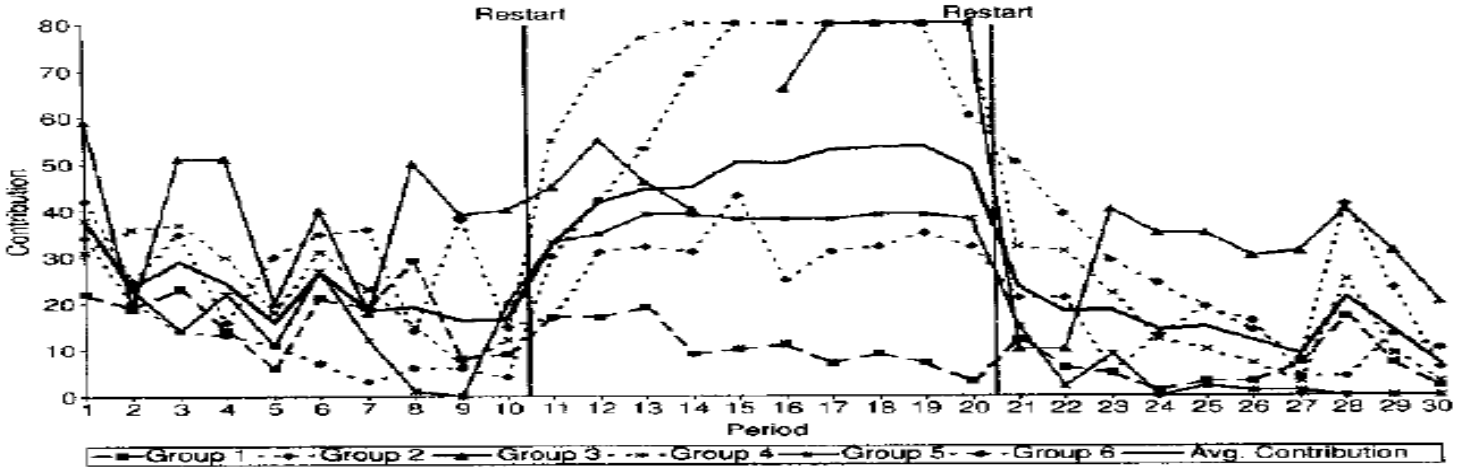


FIGURE 1. GROUP CONTRIBUTION LEVELS IN MP (PURDUE)

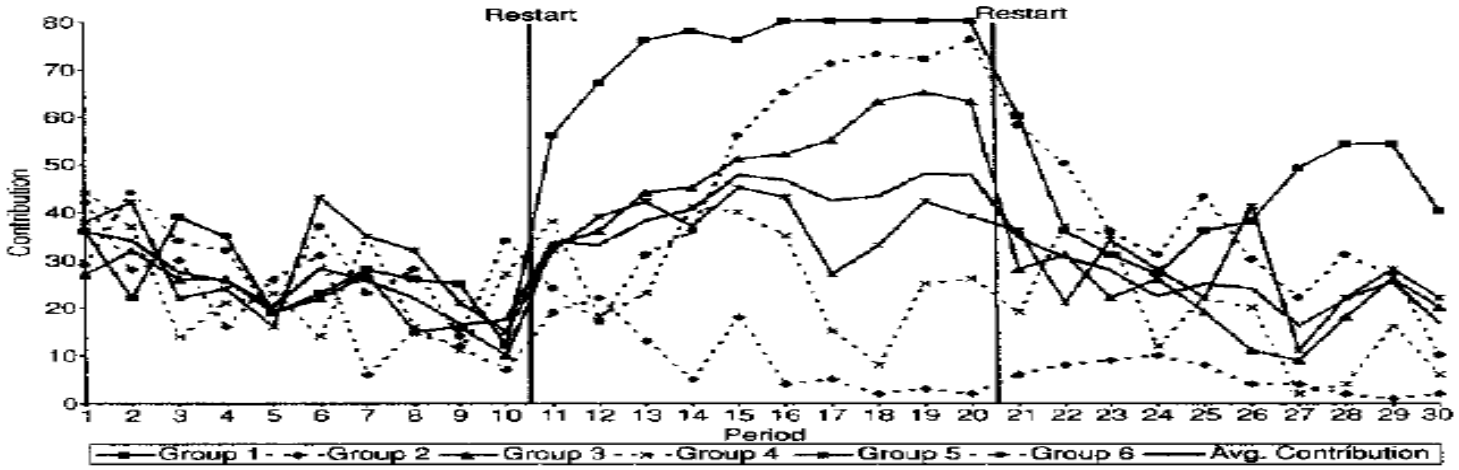


FIGURE 2. GROUP CONTRIBUTION LEVELS IN MP (GATE)

Messy Figure! But shows that monetary punishment (period 11-20) increases contributions (in line with Fehr& Gächter (AER 2000)).

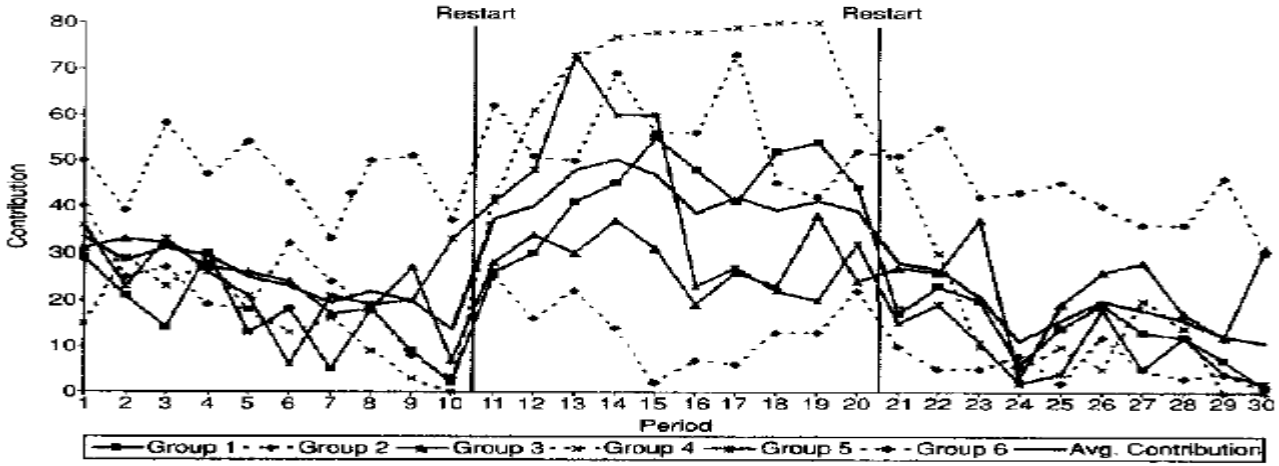


FIGURE 3. GROUP CONTRIBUTION LEVELS IN NP (PURDUE)

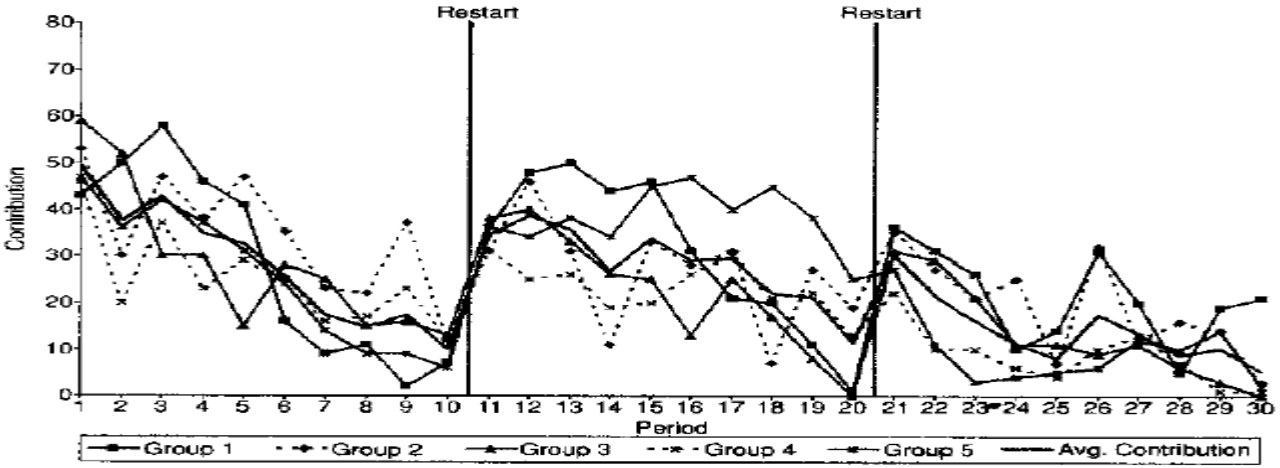


FIGURE 4. GROUP CONTRIBUTION LEVELS IN NP (GATE)

The Figure shows that non-monetary punishment (period 11-20) increases contributions. The effect of monetary and non-monetary punishment is initially similar, but over time (periods) the effect of monetary punishment is larger.

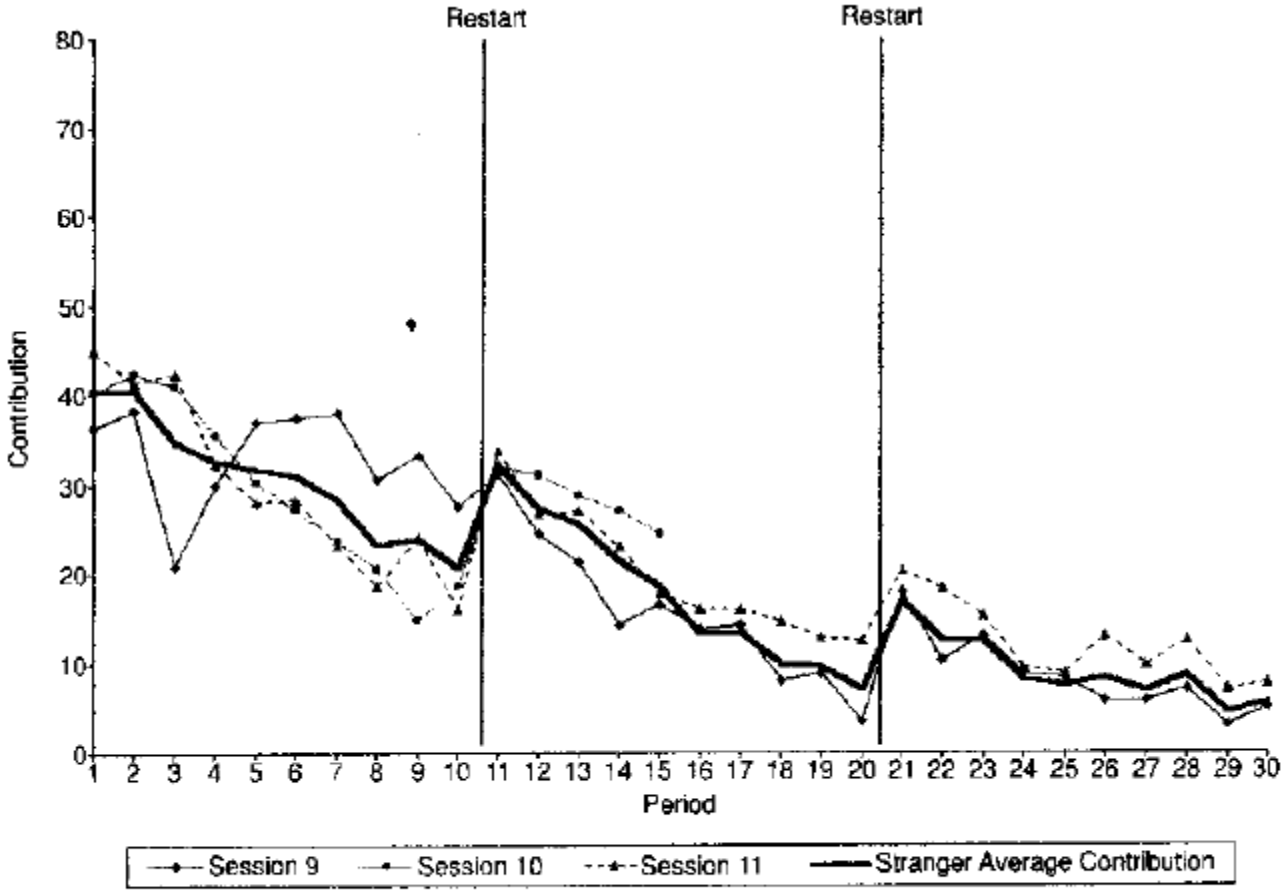


FIGURE 5. GROUP CONTRIBUTION LEVELS FOR EACH NS SESSION

The Figure shows the effect of non-monetary punishment with stranger matching; suggests an effect of non-monetary sanctions also with stranger treatment (comparing periods 11-20 with period 21-30); but the results are difficult to interpret as both the matching (from partner to stranger) and the punishment changes between period 1-10 and period 11-20.

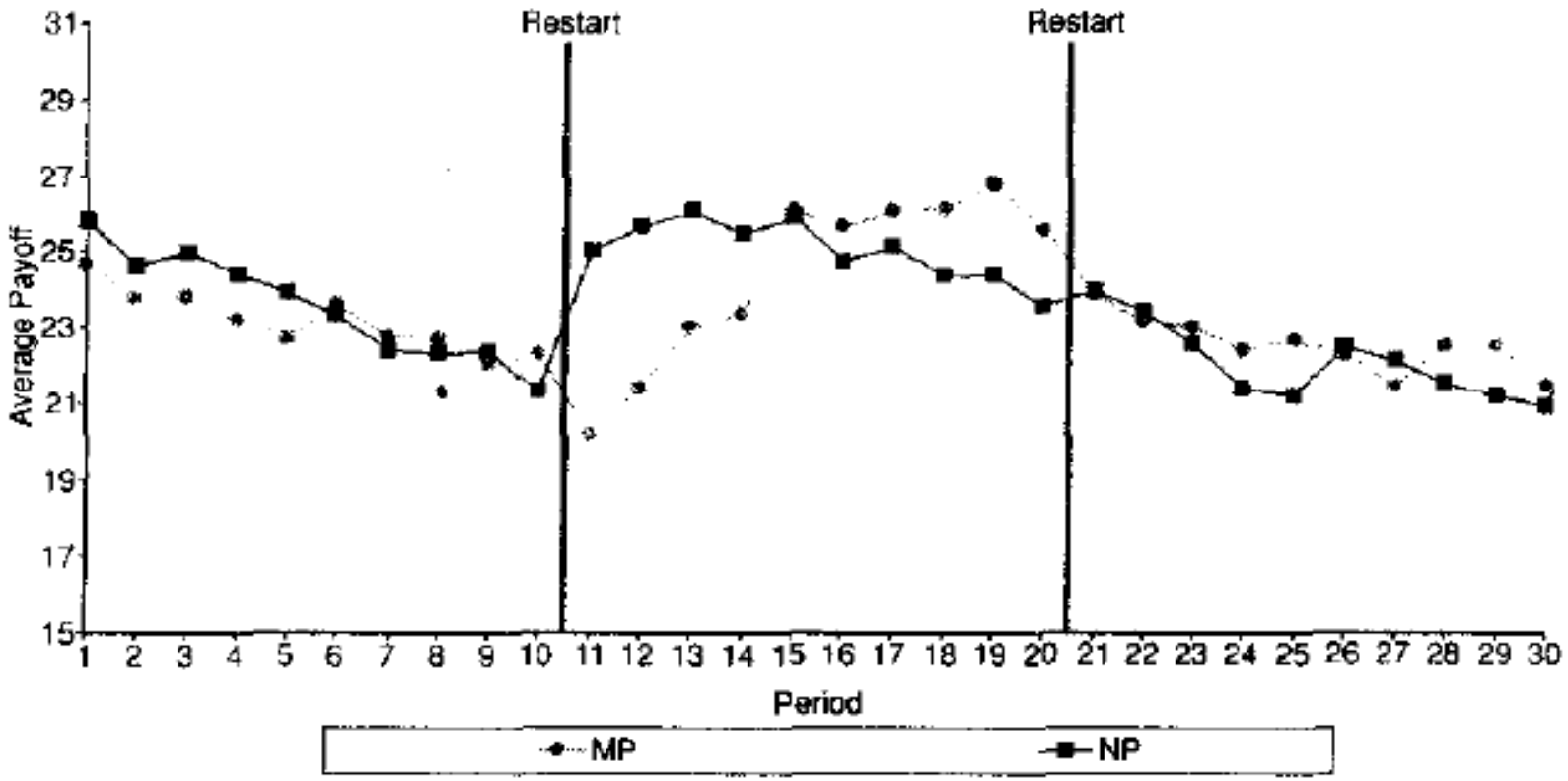


FIGURE 6. AVERAGE PER PERIOD EARNINGS IN MP AND NP

The Figure shows that the average earnings are higher with non-monetary punishment than monetary punishment in the first five periods (periods 11-15), but for the last five periods (period 16-20) the average earnings are somewhat higher with monetary punishment.

Conditional Cooperation in the Lab and Cooperation in the Field (Rustagi et al. Science 2010)

Aim: Test if conditional cooperation in the public goods game is related to cooperation in the field (the hypothesis is based on that conditional cooperators are more successful at managing their commons as they are more cooperative, and that they use costly monitoring to achieve more cooperation; engaging in costly monitoring is like a contribution to a public good).

Sample: 679 individuals from 49 forest user groups in Ethiopia. The forest user groups have been given the rights to use and manage different forest areas as a common property resource (one group is responsible for one area). Best for the group if everyone in the group cooperates and adheres to internal rules decided by the group, but the individual members have an incentive to free-ride and for instance sell extra fuelwood. Members of the group can engage in monitoring (costly in time and effort), which involves conducting patrols through the forest.

Measurement of conditional cooperation in the lab: 679 individuals from the 49 forest user groups play a public goods game using the design of Fischbacher et al (Economics Letters 2001). Player types, including conditional cooperators, are defined based on behavior in the public goods game.

Measurement of cooperation and costly monitoring in the field: Cooperation in the field is measured as ”potential crop trees” (PCT) per hectare; survey data collected from individual members on the number of hours per month spent on monitoring the forest area.

Table 1. Criteria for identifying behavioral types and their share in our sample. We follow (*10*) and use Spearman's ρ between a participant's and a partner player's contribution to elicit a participant's behavioral type. We classify a player as conditional cooperator if the Spearman's ρ is positive and significant at $P \leq 0.001$, weak conditional cooperator if the Spearman's ρ is positive and significant at $0.001 < P < 0.05$, free rider if a player consistently contributes zero independent of the partner player's contribution or contributes at most the smallest positive amount in only one of the seven decisions, altruist if a player consistently contributes the entire endowment regardless of the partner's contribution, and hump-shaped if the contribution increases up to a point with the partner's contribution and then decreases (based on visual examination).

Behavioral type	*N*	%	Mean Spearman ρ
Conditional cooperator	231	34.02	0.99
Weak conditional cooperator	79	11.63	0.86
Free rider	78	11.49	–0.08
Hump-shaped	20	2.95	–0.04
Altruist	15	2.21	0.00
Other	256	37.70	0.15
All players	679	100.00	0.48

Player types based on the behavior in the public goods game.

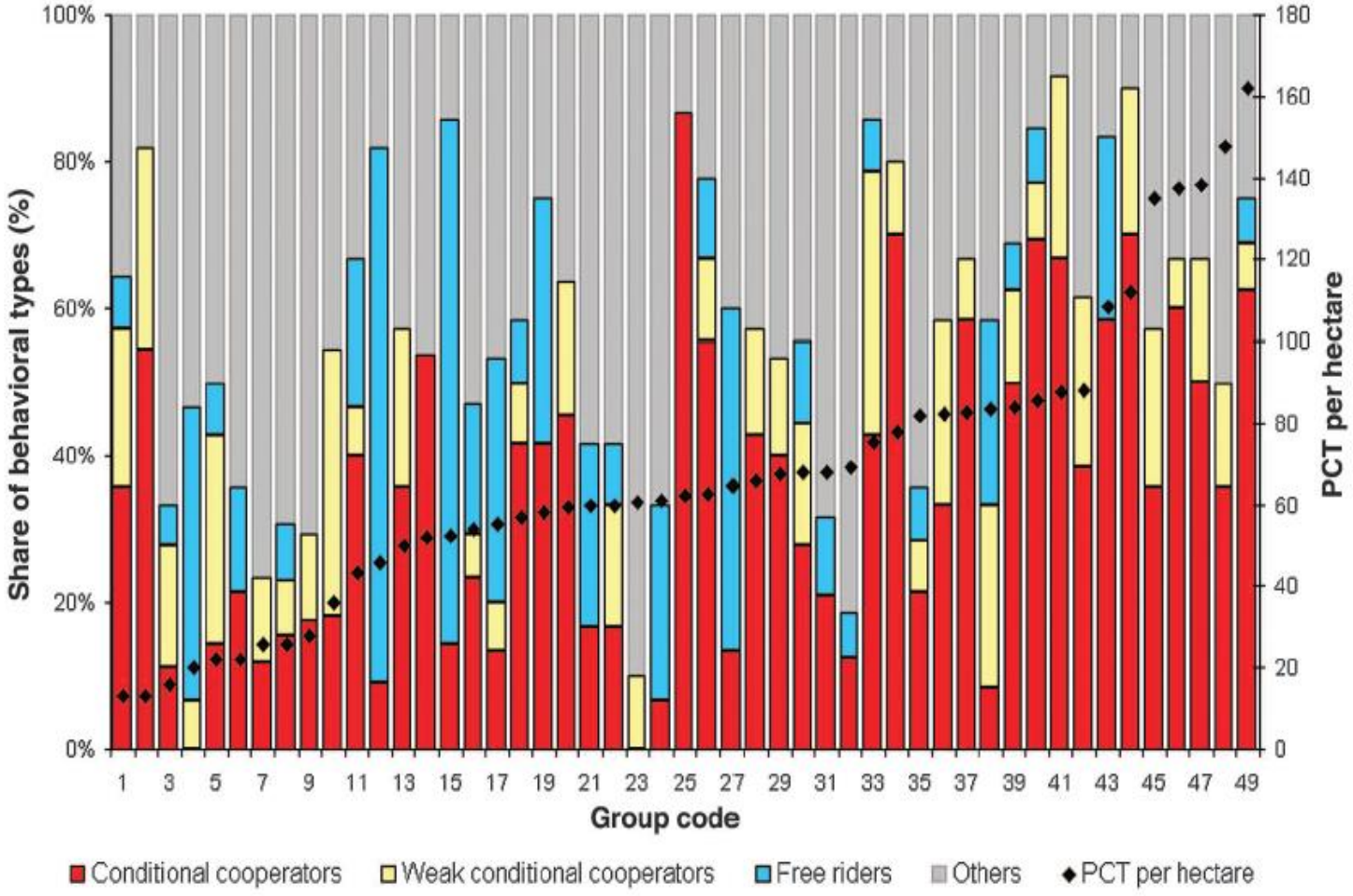


Fig. 1. Forest management outcome as measured in potential crop trees (PCT) per hectare and the relative shares of the main behavioral types in a group. The groups are sorted by PCT. Each bar represents a group engaged in the management of forest commons identified by its numerical code. There is large variation in the forest management outcome (min = 13, max = 161.9, SD = 35.2) and in the share of conditional cooperators (min = 0%, max = 86.7%, SD = 21.5%) and free riders (min = 0%, max = 72.7%, SD = 17.2%) across groups.

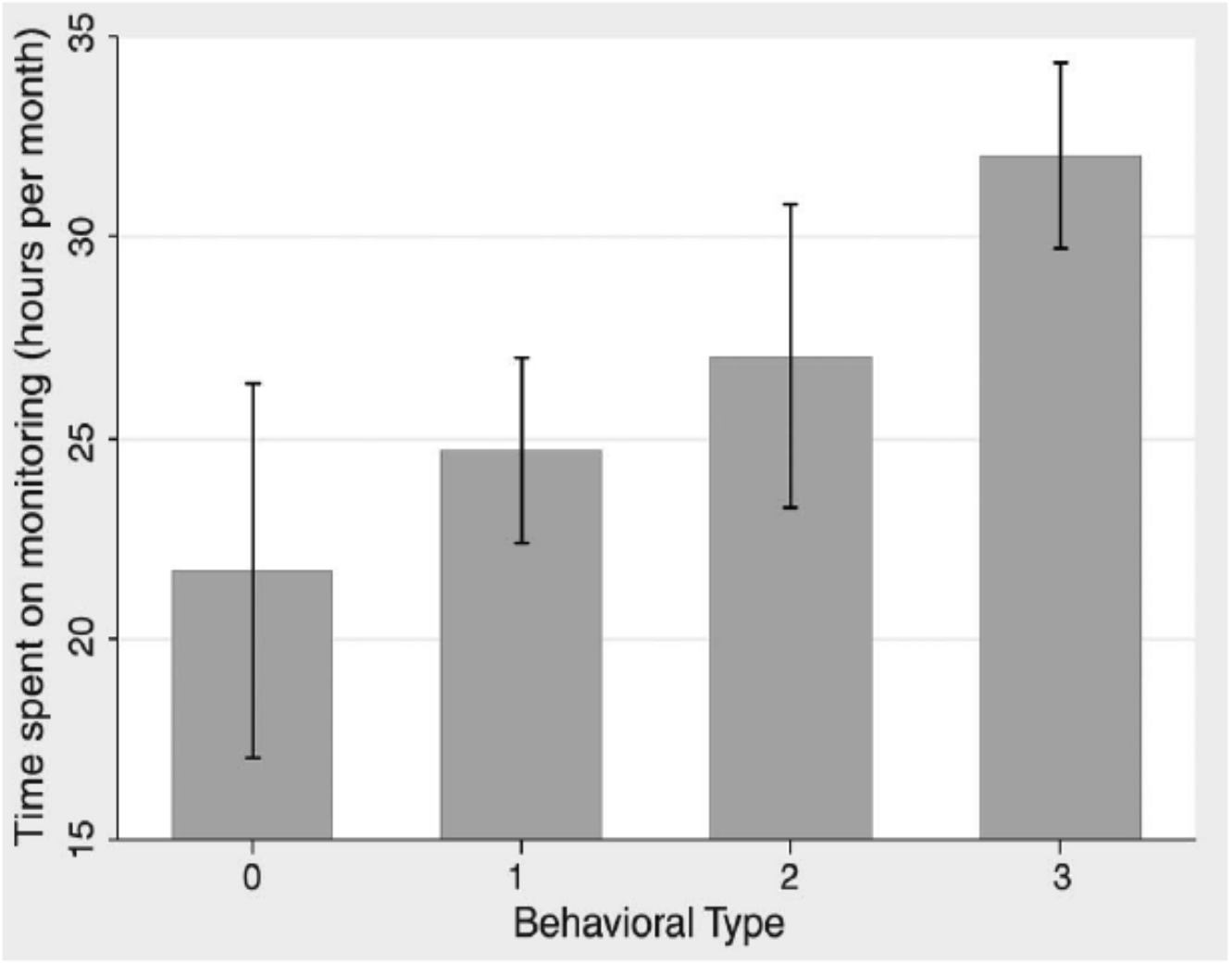
The ”black squares” denote PCT per hectare (the field measure of cooperation in the forest user groups); observations are sorted from lowest to highest PCT per hectare. The red bars denote the fraction of conditional cooperators in each forest user groups; it increases on average with higher PCT per hectare.

Table 2. Forest management outcome, conditional cooperation, and structural variables. The dependent variable is forest management outcome, measured in PCT per hectare. The independent variables are conditional cooperator shares, market distance, and time. Additional controls include elevation, group size, share of female members, and heterogeneity in livestock ownership. Ordinary least squares (OLS) estimates with robust standard errors in parentheses. ***$P < 0.01$.

	Dependent variable: Forest management outcome	
Variables	1	2
Conditional cooperator share		52.085*** (13.117)
Market distance	−22.779*** (4.355)	−20.568*** (4.057)
Time	36.479*** (6.409)	32.185*** (6.004)
Constant	105.325*** (21.719)	81.438*** (19.186)
Additional controls	Yes	Yes
Adjusted r^2	0.58	0.67
Observations	49	49

Testing if the conditional cooperator share is associated with the field measure of cooperation (PCT per hectare); a 10 percentage unit increase in the share of conditional cooperators increase PCT per hectare by about 5.

Fig. 2. Average time spent on monitoring by behavioral types. Behavioral types are as follows: 0, free rider; 1, other types; 2, weak conditional cooperator; 3, conditional cooperator. Mean ± SEM per type.



Conditional cooperators (type 3 in the Figure) spend more time on monitoring the forest area than free riders, other types and weak conditional cooperators.

Table 3. Costly monitoring, conditional cooperation, and structural variables. The dependent variable is the average time a group member spends monitoring the forest, measured in hours per month. The independent variables are the share of conditional cooperators in a group, market distance, and time. Additional controls include monitoring difficulty, group size, share of female members, and heterogeneity in livestock ownership. OLS estimates with robust standard errors in parentheses. ***$P < 0.01$, **$P < 0.05$.

	Dependent variable: Time spent on monitoring	
Variables	1	2
Conditional cooperator share		23.782*** (8.700)
Market distance	−5.972*** (1.518)	−4.951*** (1.543)
Time	11.428*** (3.814)	9.079** (3.477)
Constant	49.467*** (16.464)	42.092** (15.553)
Additional controls	Yes	Yes
Adjusted r^2	0.31	0.42
Observations	45	45

Testing if the conditional cooperator share is associated with the time spent monitoring the forest area; a 10 percentage unit increase in the share of conditional cooperators increase the time spent monitoring the forest area by about by about 2.5 hours per month.

Costly Punishment of Free-Riders in the Lab and Cooperation in the Field (Kosfeld and Rustagi AER 2015)

Aim: Test if punishment of free-riders in the lab is related to cooperation in the field.

Sample: 51 forest user groups in Ethiopia (see the previous study). The members of a group elects a leader for typically a five-year period. The study focus on the behavior of the 51 group leaders in the lab and cooperation in the groups in the field.

Measurement of punishment of free-riders in the lab: A third-party punishment game conducted. In the first stage members of the group play a public goods game; group members are anonymously paired and endowed with 6 Birr and decide to give 0, 2, 4, or 6 Birr to the public good and the amount given is multiplied by 1.5. Ín the second stage group leaders (who do not participate in the first stage) are endowed with 10 Birr and after observing the cooperation decision of anonymous members in the first stage can deduct points of player 1 and/or player 2; it costs the leader 1 Birr to deduct the payoff of a member by 3 Birr. The strategy method used to elicit punishment behavior of the leaders. Leaders divided into different types based on the behavior in the third-party punishment game.

The same public goods game as in the previous study also conducted to measure the fraction of conditional cooperators in each group.

Measurement of cooperation in the field: Cooperation in the field is measured as ”potential crop trees” (PCT) per hectare.

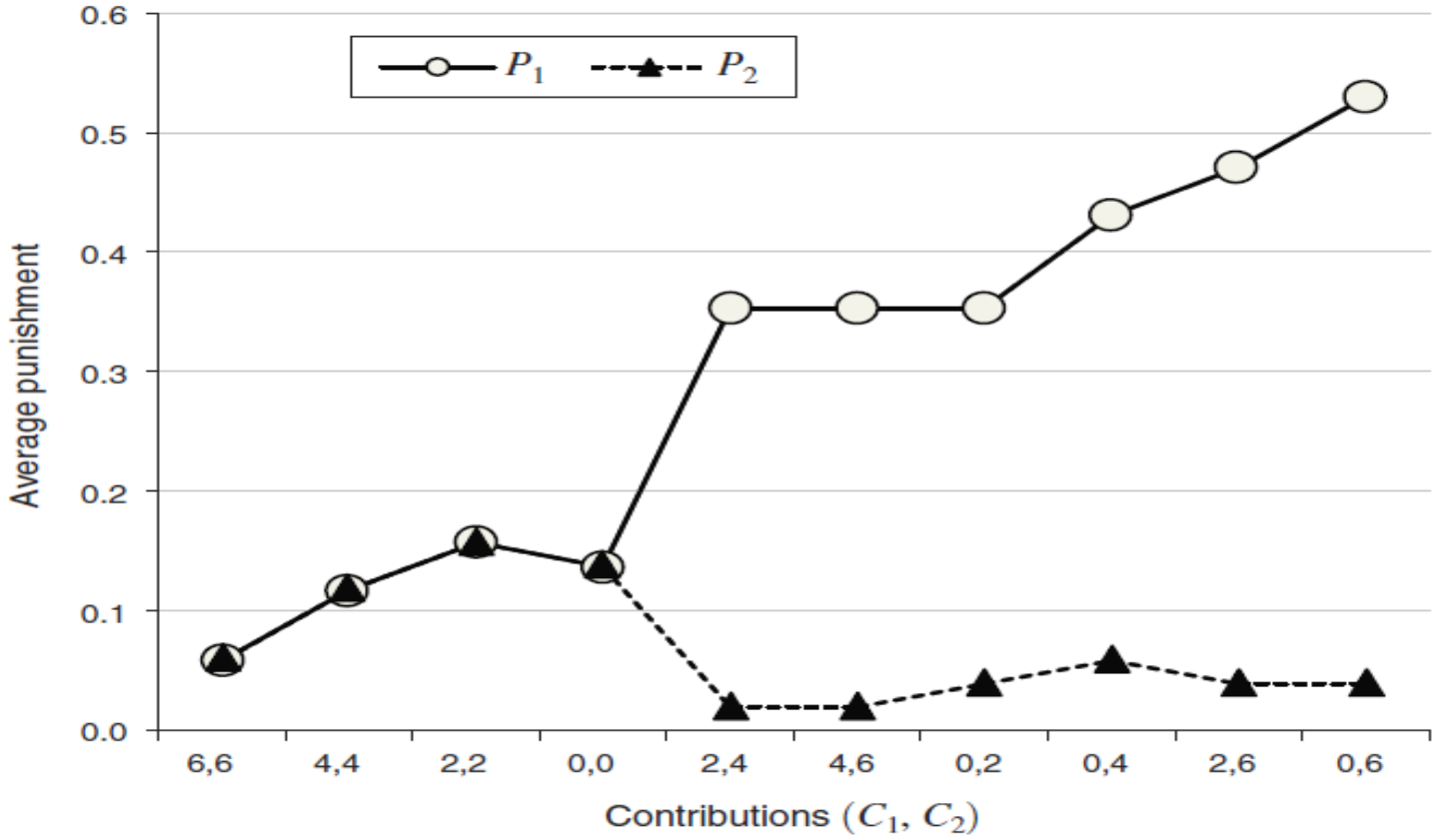


FIGURE 2. AVERAGE PUNISHMENT FOR DIFFERENT CONTRIBUTIONS OF PLAYER 1 AND 2

Notes: The horizontal axis indicates the contributions of player 1 and 2, respectively. The vertical axis indicates the average punishment in Birr given by leaders. The continuous line with circles indicates average punishment of player 1 (P_1) and the dotted line with triangles indicates average punishment of player 2 (P_2).

Punishment behavior of group leaders in the third-party punishment game. The circles show the punishment of the player that contributes the least to the public good in the pair and the triangles show the punishment of the player that contributes the most to the public good (the initial four points on both lines are when both players contribute the same).

TABLE 4—LEADER TYPES AND PUNISHMENT MOTIVES

Leader type	Definition	Frequency	Verbal statement (examples)
Equality driven (L_{EQ})	Punishes exclusively deviations from the equality norm	$n = 14$	Make payoffs nearly equal
Equality and efficiency driven (L_{EQEF})	Punishes deviations from equality and efficiency norms	$n = 4$	Make payoffs nearly equal and punish those who contribute less
Antisocial (L_{AS})	Punishes irrespective of deviations, in particular when players contribute their full endowment	$n = 4$	It is so much fun to reduce income; I want to reduce income of those who have
Non-punisher (L_{NP})	Does not punish	$n = 29$	I prefer to have money in my pocket; they get what they have; I do not like to punish

Leaders divided into leader types based on the third-party punishment game.

TABLE 6—LEADER TYPES AND GROUP PERFORMANCE

	No controls	Group level controls	Village fixed effect	Leader type dummies	Vice leaders dropped	Two influential obs. dropped	Leader controls (age, education, clan)	Clan, settlement, and Gini land
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L_{EQ}	−1.186	0.097	−0.638	−6.732	−0.990	0.355	−0.484	0.444
	(1.896)	(1.460)	(1.303)	(7.635)	(1.476)	(1.066)	(1.259)	(1.489)
L_{EQEF}	3.200*	2.349**	2.494***	24.732**	2.739**	2.050***	2.494***	2.932***
	(1.595)	(0.898)	(0.875)	(11.029)	(1.128)	(0.627)	(0.827)	(0.826)
L_{AS}	−9.795***	−6.834***	−7.404***	−19.820**	−8.373**	−8.042***	−8.355***	−9.183***
	(3.315)	(1.809)	(2.396)	(9.105)	(3.032)	(2.495)	(2.329)	(2.500)
CC Share		55.677***	34.624**	27.855*	39.896*	40.032***	38.747***	41.864***
		(13.529)	(15.160)	(15.337)	(21.768)	(13.897)	(13.886)	(14.601)

Testing if the leader types are associated with the field measure of cooperation (PCT per hectare). Leaders that do not punish is the baseline category; leaders that punish based on both equality and efficiency motives associated with the best group performance and leaders punishing based on antisocial motives associated with the worst group performance.

Note that the leader type variables are defined in terms of punishment points within each type in all regressions except (4). Easiest to interpret regression (4) with dummy variables for type; groups with leaders that punish based on both equality and efficiency have 25 PCT per hectare more on average than the baseline group and groups with antisocial leaders have 20 PCT per hectare less on average than the baseline group. CC Share is the fraction of conditional cooperators in the group; other controls not shown here.