# Welfare Implications of Peer Punishment in Unequal Societies

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**Abstract**

We show that peer sanctioning increases cooperation in public goods experiments more in unequally endowed groups than in equally endowed groups. Punishment results in a redistribution of wealth from high to low endowment players within groups.

*JEL classification: C9, D63, H41, I3, Q2, Z13*
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## 1 Introduction

A growing body of experimental literature is devoted to peer punishment as a means of enhancing cooperation in public goods experiments. Contrary to theoretical predictions, recent studies (Fehr and Gaechter, 2000; Masclet et al., 2003; Cinyabugumu et al., 2004; and Carpenter et al., 2004) find that people punish in repeated and in one-shot games. Evidently people honour social norms such as fairness and reciprocity, and are generally prepared to punish others who do not adhere to these norms even if such punishment is costly to themselves (Bowles and Gintis, 2000).

This study investigates the effectiveness of punishment in maintaining cooperation in the provision of public goods in communities characterized by inequality. Inequality is introduced via varying endowments within groups. To our knowledge it is the first study that explores this question in an experimental context.

Our sample includes individuals from nine fishing communities along the West Coast of South Africa. They are familiar with social dilemmas: externally imposed inequality in the form of a fishing quota allocation process perceived as unfair and arbitrary has lead to strife within these communities. We explore the impact of inequality, specifically whether internal peer punishment functions effectively in such contexts. The implications of punishment on group welfare and within-group inequality is investigated.

## 2 Experimental Design

Our experiment uses a linear public goods (PG) design similar to that used by Fehr and Gaechter (2000). Self-interested individuals have incentives to free-ride while the social optimum requires that all players cooperate. The experiment consists of two parts and four treatment conditions. In the first part there is: i) a treatment using the Voluntary Contribution Mechanism (VCM)

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where all players within groups receive equal endowments, and ii) a VCM treatment where players within groups receive unequal endowments. In the second part the same groups participate in: iii) a VCM treatment with equal endowments and peer punishment, and iv) a VCM treatment with unequal endowments and peer punishment. There are seventy groups with equal endowments, and seventy-three groups with unequal endowments.

In total 569 individuals are randomly assigned to groups of four, and remain in the same group for the entire session (fixed matching). Both sessions involve two practice rounds and 6 rounds with real money at stake. In every round each of $n = 4$ subjects receives an endowment of $y$ Experimental Currency Units (ECUs) or tokens, of which they may invest $g_i$ ECUs into a public account. In the equal treatment all players receive 40 ECUs. In the unequal treatments 2 players each receive 30 ECUs and 2 players 50 ECUs. Once assigned a low or high endowment, that endowment is allocated in every subsequent round. The pay-off function for player i used in the VCM treatment and the first stage of the punishment treatment is

$$\Pi_{Ii} = (y - g_i) + 0.5 \sum_j g_j \tag{1}$$

for each round, where 0.5 is the marginal per capita return (MPCR) from public good contributions. The total payoff from the VCM treatment is the sum of all six rounds' pay-offs.

The Punishment treatment involves a second stage where subjects can reduce the first stage payoff ($\Pi_{Ii}$) of other players by allocating punishment points. The cost of a punishment point is fixed at $c_{ij}$=1 ECU, and each point received reduces the payoff by 5 ECUs. Subjects know the endowments and contributions of other players before making punishment decisions for the round. Punishment points are awarded simultaneously across the group, and individuals are only given the aggregate number of punishment points allocated to them in each round. The pecuniary pay-off ($\Pi_i$) for player $i$ from both stages of the punishment treatment is

$$\Pi_i = \begin{cases} \Pi_{Ii} - \left(5 \sum_j p_{ji} + \sum_j c_{ij} p_{ij}\right) & \Pi_i \geq 0 \\ 0 & \text{otherwise,} \end{cases} \tag{2}$$

where player $i$ within a group assigns $p_{ij}$ punishment points to player $j$.

Aggregate pay-off from this treatment is the sum of $\Pi_i$ over six rounds. All parameters in the pay-off function are known by the participants up front.

The experiments are manually performed within communities and last for $2 - 3$ hours. Each ECU earns the participant 10 cents (US 2 cents) and on average participants earn R110 (US$22), which translates to about two days' wages.

# 3 Results of the Experiments

In both the equal and unequal VCM treatments, average contributions, ranging between 43% and 47%, decline over 6 rounds. This is in line with experiments with students (Fehr and Schmidt (1999) and Cardenas and Carpenter (2003)).

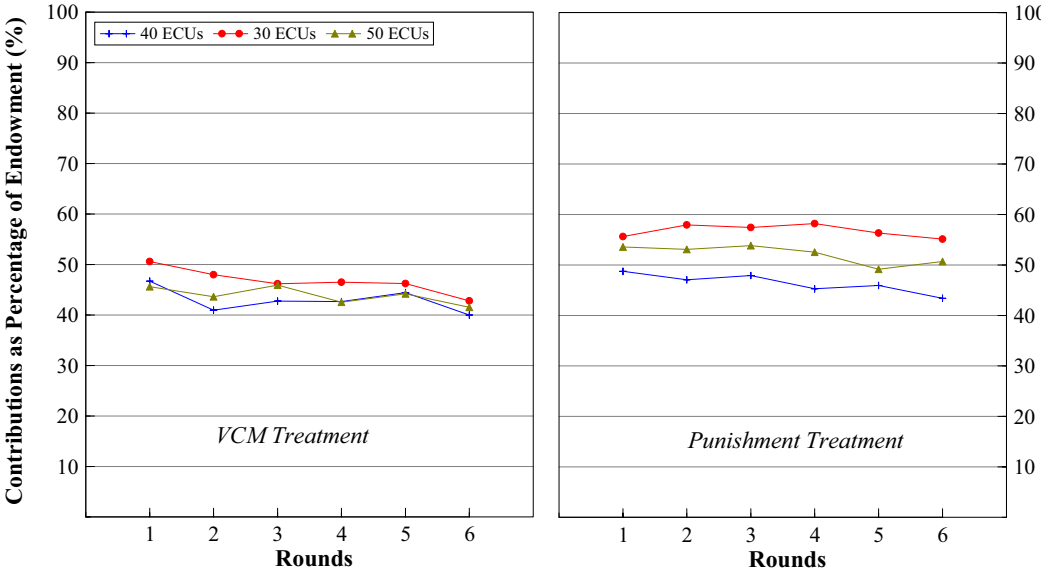


**Figure 1:** Average fraction of endowment contributed in the VCM and Punishment treatments, for players in equal groups (40 ECUS) and for low endowment (30 ECUs) and high endowment (50 ECUs) players in unequal groups.

Spearman's rank correlation test indicates that the increase in average contributions between the VCM and Punishment treatments is significant for the equal ($\rho = 0.421$; $p < 0.0001$) and unequal ($\rho = 0.278$; $p < 0.0001$) treatments (See Figure 1). This amounts to an average increase of 2.7% in equal groups and 8% in unequal groups. For both VCM ($z = -2.98$; $p < 0.0029$) and Punishment ($z = -8.84$; $p < 0.0001$) treatments the two-sample Wilcoxon ranksum test confirms that the average fraction of contributions in equal groups is significantly lower than in unequal groups[1].

A slight difference in the fraction contributed by low and high endowment players in unequal groups is apparent in the VCM treatment (See Figure 3.1). However, in the Punishment treatment the average fraction contributed by low endowment players is 5% above that of high endowment players[2].

Free-riding is generally punished more severely in unequal groups than in equal groups (see Visser and Burns, 2005). Low endowment players receive less punishment than high endowment players in the unequal treatments (13.3 vs 14.6 punishment points), and also punish more than either high endowment players and players in equal groups if we control for relative free-riding (negative deviation from the group average fraction contributed).

While punishment is effective in maintaining cooperation in the voluntary contribution mechanism, it is important to consider its overall welfare effects. Figure 2 shows the evolution in earnings over rounds for the VCM and Punishment treatments respectively.

[1]Similar results are obtained using pooled OLS regressions,lower limit tobit models, and also when using multilevel modelling techniques controlling for individual and group random effects (with individuals nested within groups). In the multilevel model the unequal treatment is positive but not significant for the VCM, while the result for the punishment treatment remains unchanged.

[2]This result is significant according to the two sample Wilcoxon ranksum test for both treatments (VCM: $z = 1.86$; $p < 0.07$, Punishment: $z = 3.43$; $p < 0.0006$).

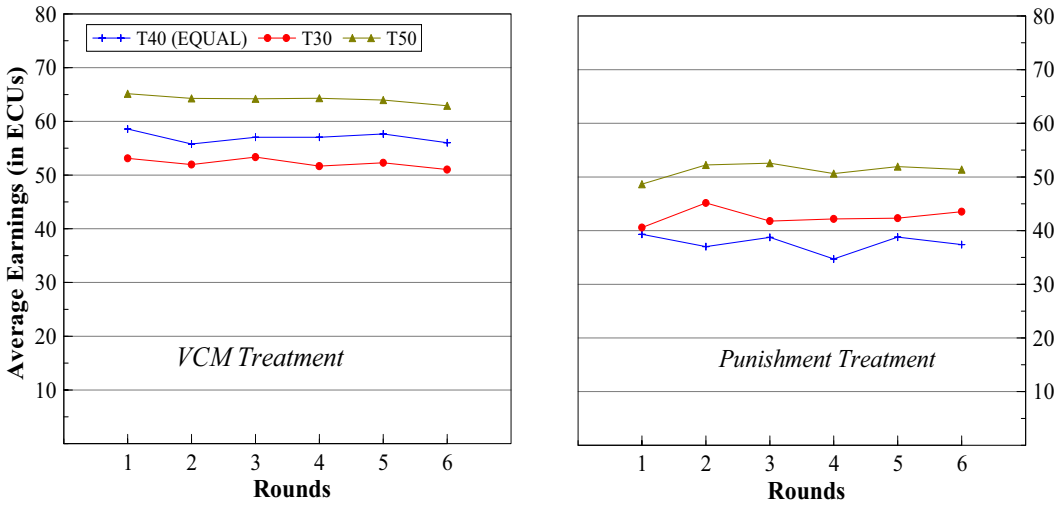


**Figure 2:** Average earnings in the VCM and Punishment treatments for players in equal groups (40 ECUS), and for low endowment (30 ECUs) and high endowment (50 ECUs) players in unequal groups. The social optimum here is 80 ECUs, while expected earnings at the Nash Equilibrium is 30, 50 and 40 ECUs for low endowment, high endowment and equal players, respectively. Net gain from group cooperation is the difference between average earnings and the endowment received.

The maximum average achievable earnings (80 tokens) occurs at the social optimum when all individuals contribute their full endowment to the public good and no-one allocates any punishment points. In contrast, expected earnings when all players free-ride at the Nash Equilibrium can never exceed the initial endowment that each player receives (30, 40 or 50 tokens). An individual's net gain (on the initial endowment) from the group's investment in the public account is the difference between earnings and tokens received in each round. Any wealth in excess of the endowment equals net gain from cooperation within the group (even though a player may choose to free-ride herself)[3].

In the VCM treatment players in equal (40 ECUs) and unequal groups (30 ECUs and 50 ECUs) do better on average than if everyone were to follow their Nash-best strategy by free-riding. For example, consider earnings for the second round in the VCM treatment for each group (see Figure 2): high endowment players earn 64 ECUs, and their net-gain from cooperation is $64 - 50 = 14$ ECUs on average. Low endowment players in unequal groups earn 52 ECUs on average, implying net gains of $52 - 30 = 22$ ECUS. Players in equal groups earn 56 ECUs on average, which translates to a $56 - 40 = 16$ ECU net gain.

Punishment has a severe negative effect on earnings: only low endowment players manage to consistently earn more than their original endowment for each round. In contrast, in all 6 rounds players in the equal groups earn less than their endowment on average. Using the second round of the Punishment treatment once more as illustration we note the following: high endowment players in unequal groups earn 52 ECUs on average, resulting in a net gain of $52 - 50 = 2$ ECUs for the round. Earnings for low endowment players in unequal groups is 45 ECUs on average, with net gains of $45 - 30 = 15$ ECUS. Players in equal groups earn only 37 ECUs on average, resulting in a net loss of 40-37=3 ECUs on their initial endowment.

Comparing the (cumulative) overall earnings for the VCM (Table 1, Column 2) with the overall first stage earnings (prior to the allocation of punishment points) in the punishment treatment (Table 1, Column 3), it is clear that on average sanctions do lead to efficiency gains in earnings. However, once punishment is allocated overall average earnings are reduced substantially (Table 1,

[3]In the VCM treatment, the fixed marginal per capita return from the public good clearly favours 30 token players and 40 token players over 50 token players. For instance, in the unequal treatment full contribution by both low and high endowment players results in returns of 50 [80-30] ECUs and 30 [80-50] ECUs respectively.

**Table 1:** Average overall earnings after the VCM and Punishment treatments.

| | *AVERAGE OVERALL EARNINGS (ECUs)* | | |
|---|---|---|---|
| | VCM | StageI Punishment (before Punishment) | Final Punishment (after Punishment) |
| EQUAL | 339.69 | 344.73 | 221.98 |
| UNEQUAL | 348.16 | 369.59 | 281.44 |
| T50 | 383.90 | 401.96 | 307.48 |
| T30 | 312.68 | 337.45 | 255.57 |

Column 4): by 34.7% for equal groups and by 19.16% for unequal groups. Spearman's rank correlation test indicates that for each of the low endowment ($\rho = 0.124$; $p < 0.0001$), equal ($\rho = 0.288$; $p < 0.0001$) and high endowment ($\rho = 0.2; p < 0.0001$) players average earnings are significantly lower in the Punishment than in the VCM treatment.

Cinyabuguma et. al (2004) find that sanctions lead to low (and in some cases negative) net efficiency gains in overall earnings, and show that this is mainly due to costly punishment and misdirected punishment aimed at high contributors. They obtain similar results by calculating overall earnings using Fehr and Gaechter's (2000) data (original results were reported in terms of earnings per round). Our results (discussed in Visser and Burns, 2005) also show a U-shaped pattern of punishment, with both free-riders and high contributors being targeted for punishment. In treatments with punishment and counter-punishment, Nikiforakis (2005) similarly finds that losses incurred with respect to earnings in the VCM are never regained over rounds, and that punishment opportunities are therefore not welfare improving.

An important welfare implication for unequal groups is that the overall earnings difference between the higher endowment players and the lower endowment players (VCM: 383.89 - 312.67 = 71.21 ECUs; Punishment: 307.48 - 255.57 = 51.91 ECUs) is 27.1% lower after the Punishment treatment (Table 1, Column 4) than after the VCM treatment (Table 1, Column 2). This indicates that there is a re-distribution of within-group wealth, which can be directly attributed to the use of peer punishment. This result is further verified by considering the average within-group variance of final earnings for both treatments, as shown in Figure 3. Average within group variance is used here as a simple measure of inequality within groups (Foster and Sen, 1997).

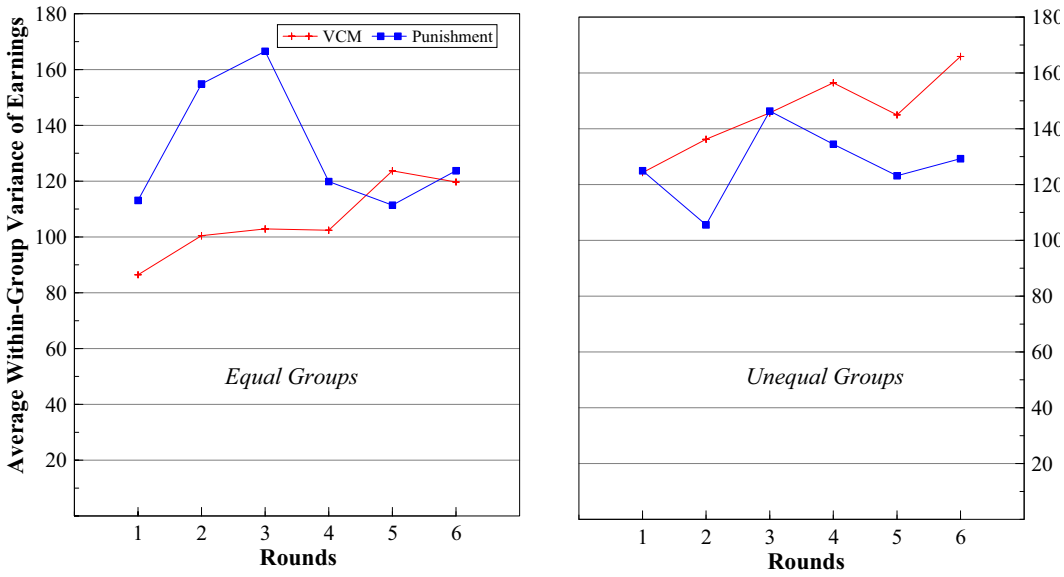


**Figure 3:** Average within-group variance of earnings of the VCM and Punishment treatments for players in equal and unequal groups.

For Equal groups the within-group variance is lower in the VCM than in the Punishment treatment on average. In contrast, for unequal groups the within-group variance is greater in the VCM treatment than in the Punishment treatment on average. Spearman's rank correlation test confirms that the average within-group variance of the equal groups ($\rho = -0.1440$; $p < 0.0001$) and the unequal groups ($\rho = 0.6011$; $p < 0.0001$) in the VCM treatment is significantly different from that in the Punishment treatment. Moreover inequality is on average lower in the Unequal groups than in Equal groups in the Punishment treatment, as indicated by the Wilcoxon ranksum test ($z = -3.015$; $p < 0.0026$).

# 4 Conclusion

This study has focussed on the behaviour of 569 people in low income areas along the West coast of South Africa, whose livelihoods depend on subsistence and small-scale commercial fishing. Results indicate that peer punishment as a sanctioning mechanism aimed at increasing cooperation is used more successfully in unequal than in equal groups. Group welfare in the presence of sanctions is higher for unequal groups than for equal groups. Moreover, in the Punishment treatment relative net gains for low endowment players are substantially higher than those of high endowment players in unequal groups. This results in redistribution of wealth from high to low endowment players in unequal groups, and lower levels of within-group inequality as the game proceeds. The opportunity for punishment allows low endowment players, who stand to gain more (per token) from group cooperation, to express their dissent with free-riding and to redress within-group inequality. Given the size of our sample we feel confident that these findings can be generalized to other unequal communities.

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