Bridging the Great Divide in South Africa: Inequality and Punishment in the Provision of Public Goods

Martine Visser* †

Martine.Visser@economics.gu.se

Justine Burns‡

jburns@commerce.uct.ac.za

August 2006

Abstract

We explore the effect of income inequality and peer punishment on voluntary provision of public goods in an experimental context. Our sample draws from nine fishing communities in South-Africa where high levels of inequality prevail. We find that aggregate cooperation is higher in both the voluntary contribution mechanism (VCM) and punishment treatments for unequal groups. Once peer sanctioning is introduced over-contribution by low relative to high endowment players observed in the VCM

*Göteborg University, Department of Economics, Telephone: +46 (0)31 773 1317. Address: Vasagatan 1, Box 640, 405 30 Göteborg, Sweden.

†We would like to thank the National Research Foundation of South Africa, as well as Sida for funding the research. We appreciate the thoughtful comments by Olof Johansson-Stenman, Peter Martinsson, Martin Dufwenberg, Dan Ariely, Nikos Nikiforakis, Douglas Davis, Jeffrey Carpenter and Juan-Camillo Cardenas. We would also like to thank our research assistants and all the people from the communities we worked with.

‡University of Cape Town, School of Economics, Telephone: +27 (0)21 650 3757. Address: University of Cape Town,Private Bag, Rondebosch, 7700, South Africa.

treatment is significantly enhanced. Demand for punishment by low and high endowment players are similar, irrespective of differences in relative costs, and in unequal groups free-riding is punished more, specifically by low endowment players. We observe inequality aversion both in endowments and with respect to the interaction of endowments and contributions: high endowment players receive more punishment, but also receive more punishment for negative deviation from the group mean share.

JEL classification: C9,D63,H41,Q2 Keywords: Inequality, cooperation, punishment, public goods experiments

1 Introduction

Resolving social dilemmas is particularly important in developing countries where centralized regulation is missing or ineffective. We study the provision of a public good among nine South African fishing communities, in order to shed light on the complex interaction of inequality and social sanctioning that confronts them.

We choose this setting because it lends itself well to the issues we are interested in: individuals within the communities we study have extensive experience of social dilemmas and sanctioning since their livelihoods depend directly or indirectly on fishing. South Africa, with a Gini of 57.8, is one of the most unequal countries in the world (UNDP, 2005) and within-group inequality has increased since the end of Apartheid (Whiteford et al., 2000). Moreover, irregular allocation of fishing quota by government has resulted in externally imposed income inequality, leaving subsistence and small-scale commercial fishing communities divided (O'Roirdan, 1999). The topic is hotly debated in the media, in political fora, and within the affected communities, especially given that few alternative employment opportunities exist. Allocation of quota is generally perceived as unfair and arbitrary: complicated application procedures and exorbitant application fees restrict entry, and there is an overall lack of transparency (Isaacs et al., 2005). Outraged community members have threatened to destroy their communities, individuals have received threats to their lives, and anecdotal evidence exists of extreme cases where boat burning has occurred. In a broader sense these divisions among communities also affect their perceptions towards managing the resource, poaching, and reporting of thereof. It therefore seems im-

portant to understand how such inequality (due both to Apartheid and the current fisheries legislation) affects the welfare outcomes for the people involved.

Because the interactions we describe are difficult to study in the field, we use public goods experiments designed to replicate social dilemmas as analogy to the real phenomena. We specifically introduce treatments to study the interaction of inequality and sanctioning in a controlled environment.

Our main questions in this study are as follows: are unequal groups still able to use peer punishment to maintain cooperation, and if so, who bears the burden in provision of the public good when there is punishment? Moreover, can we expect differences in the demand for punishment or in the motivation for punishment behaviour between low and high endowment players?

The external validity of economic experiments conducted by students in labs is important to consider (see Harrison and List, 2004) when studying issues such as inequality and social sanctioning, which may have significant impacts on welfare of those involved. In keeping with our objectives we try to bridge the divide between the lab and the field by conducting an artificial field experiment with subjects from the affected communities. Studies such as those of Barr (2001, 2003) and also Cardenas and Carpenter (2003) have illustrated that rural participants in developing countries have a clear understanding of the problems related to free-riding, and use social sanctions and criticism to curb free-riding.

What we can learn from previous studies is limited in that most have focussed on either inequality or peer sanctioning, but not both. It has been reported that extremely unequal societies may be limited in their capacity to interact as communities due to a break down in co-operation (Alesina and La Ferrara, 2000; Bowles and Gintis, 2000). While some experimental studies on inequality and provision of public goods conducted with students in labs confirms this (Cherry et al., 2003; Anderson et al. 2004), others have found that inequality has a positive effect on aggregate contributions (Buckley and Croson, 2006; Chan et al., 1993, 1997, 1999). Studies of behaviour within unequal groups, although scant, report low endowment players contributing a higher share towards provision of the public good than high endowment players in repeated (Chan et al., 1997, 1999; Buckley and Croson, 2006) and one-shot (Cherry et al., 2004) public goods games.

Internal sanctions aimed at mitigating free-riding behaviour seem appropriate in developing countries given demanding administration and costs associated with external monitoring and enforcement. Studies by Tyran and Feld (2004) and Noussair and Tucker (2005) suggest that internal sanctions may be more efficient than externally enforced sanctions. Evidence from the field as mentioned above[1], as well as experimental studies on the provision of public goods (Fehr and Gächter, 2000; Bochet et al., 2005; Falk et al., forthcoming; Sefton et al. 2001; Carpenter, 2004a&b), have indicated that individuals use peer sanctioning to express disapproval and successfully coerce free-riders into contributing, even if such actions are costly to undertake. Social institutions (peer sanctioning) may therefore help to maintain cooperation in repeated interactions (Axelrod, 1997). The welfare implications of costly punishment is however not clear and a number of studies have shown that the overall outcome on welfare may actually be negative (Nikiforakis, 2005; Cinyabuguma et al., 2004; Denant-Boemont et al., 2005).

Although communication has proved effective in enhancing cooperation in heterogeneous experimental contexts (Chan et al., 2003; Walker et al., 1990; Hacket et al., 1994; Cardenas et al., 2003), empirical research on the role of social institutions in unequal societies has been limited. To our knowledge, no experiments have specifically dealt with the interaction of inequality and peer punishment.

This study involves a repeated public good experiment, combining treatments with inequality and peer sanctioning. In Part I of the experiment we compare contributions in a linear public goods experiment for equal and unequal treatments - inequality is randomly introduced via differing endowments. In Part II we introduce a peer punishment treatment for both equal and unequal groups. Each treatment has 6 periods and involves partner matching where individuals remain in the same groups over rounds.

We find that unequal groups contribute more on aggregate than equal groups and that within unequal groups low endowment players contribute a higher share of their endowment to the public good. Once sanctioning is introduced this gap in contribution share is enlarged on both counts. Reasons for this can be gleaned from studying the punishment

[1]Van Soest and Vyrastekova (2004) also cite examples of fishermen in the Bahia region in Brazil who destroyed the nets of fellow fishermen that did not adhere to quotas.

behaviour in these groups. In unequal groups free-riding elicits more punishment than in equal groups, in particular by low endowment players. Moreover, demand for punishment does not differ significantly between low and high endowment players, even though low endowment players face higher relative costs in allocating and receiving punishment. We show that low endowment players receive greater net gains from cooperation when the return from the public good is fixed. Fear of costly punishment may be an additional factor driving this difference in behaviour between low and high endowment players. Lastly, we find significant evidence of inequality aversion, not only based on differences in endowments per se, but also directed at the interaction of contribution share and endowments.

Section 2 describes the experimental design, while the results are discussed in section 3. The paper concludes with section 4.

2 Experimental Design

In this section we outline the design, parameters and procedures of the public goods experiments employed here. We also describe the field setting and recruitment process involved.

2.1 Public Goods Experiment - Basic Design

Our experiment uses a repeated linear public goods (PG) design similar to that used by Fehr and Gächter (2000) and Masclet et al. (2003). Subjects within a group each receive an endowment which they can allocate to either a private account or to a public account. Subjects are provided with a very simple pay-off formula where the Nash-equilibrium is to contribute nothing and the Social Optimum is attained when everyone in the group contributes their entire endowment.

In Part 1 of the experiment, two treatments (1A and 1B) are conducted to compare the effect of allocating equal versus unequal endowments to individuals in the voluntary contri-

bution mechanism (VCM). The first treatment (1A) consists of a standard VCM where all four players in a group receive equal endowments. In the second treatment (1B) all groups are divided into two players with high endowments and two players with low endowments. Players remain in the same groups (fixed matching) for 6 rounds. In Part 2 of the experiment we conduct further treatments (2A and 2B), with the same groups that participated in the equal and unequal treatments before, where we introduce the opportunity for players to punish each other after contributions are made.

Each of the treatment conditions are shown in Table 1.

Table 1: Treatment Conditions.

Treatments	**Equal Endowments***	**Unequal Endowments****
Part I: VCM without punishment	**IA**	**IB**
Part II: VCM with Punishment	**IIA**	**IIB**

* Four players in a group each receive 40 ECUs

** Two players in a group receive 50 ECUs (high endowments) and two players receive 30 ECUs (low endowments)

Each treatment involves 6 rounds where real money is at stake. A detailed discussion of the pay-off structure for each of the treatments follows.

2.2 Part I: Pay-off structure for the VCM treatment

In every round, each of $n = 4$ subjects receives a fixed endowment of y Experimental Currency units (ECUs) from which they may invest g_i tokens in a public account. The investment decision is made simultaneously by all players. The pay-off function used in the VCM treatment (and also stage I of the punishment treatment) is

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

for each round, where 0.5 is the marginal per capita return (MPCR) from public good contributions.

In the equal treatment, y is fixed at 40 ECUs for all players. In the unequal treatment 2 players each receive $y_L = 30$ ECUs and 2 players each receive $y_H = 50$ ECUs. The pay-off function for a high endowment player, H_1, is

$$\Pi_{I_{H1}} = (y_H - g_{H1}) + 0.5(g_{H1} + g_{H2} + g_{L1} + g_{L2})$$

and similarly the pay-off function for a low endowment player, L_1, is

$$\Pi_{I_{L1}} = (y_L - g_{L1}) + 0.5(g_{L1} + g_{L2} + g_{H1} + g_{H2}).$$

2.3 Part II: Pay-off structure for the treatment with punishment

The punishment treatment involves a second stage during which subjects can reduce the first stage payoff (Π_{Ii}) of other players. Subjects are provided with information about the endowments received by other players, along with their respective contributions. The pay-off (Π_{Ii}) for player i from both stages of the punishment treatment is

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

where player i within a group assigns p_{ij} punishment points to player j at a fixed cost c per point. Aggregate pay-off from this treatment is the sum of Π_i over six rounds.

2.4 Parameters and Procedures

The experiments were manually performed with a sample of 569 participants in field laboratories in each of nine communities[2]. Various subjects knew one another, but within the experiments the identity of other players in a group was never revealed[3]. The group size

[2]Given expected heterogeneity over these nine communities we chose to use a large sample. Few experimental studies of this size have been executed, and our findings may therefore provide further external validity to public goods experiments with much smaller sample sizes executed with students in labs.

[3]We control for the "number of persons that you know in your group", in the regression analysis section of the paper, but this is not significant.

across all treatments was four. Of the 143 groups involved 70 participated in the equal treatment and 73 in the unequal treatment. All groups participated in both the VCM treatment and the punishment treatment.

The marginal per capita return (MPCR) in each round was 0.5 for both the equal and the unequal treatments[4]. In both scenarios the return from the group account under full cooperation was therefore equal to 80 tokens.

In the equal treatments each subject received an endowment of 40 tokens. In the unequal treatments 2 players randomly received endowments of 50 tokens and 2 players randomly received endowments of 30 tokens. The rules of the game were explained in detail to each group before starting each treatment[5]. All parameters in the pay-off functions used in both VCM and punishment treatments were known by the participants in advance. Individuals were informed at the start that there would be 6 rounds during which they would play for actual money. The last round was specifically announced. Subjects were also informed that they would participate in two exercises at the start of the session.

Each player received personal decision-making sheets on which to enter information before coming forward and entering the amounts allocated to private and public accounts on a large template behind the voting booth. The templates were designed so that players could only view their own entries by using velcro to seal cardboard flaps over each person's corresponding line on the template. To further increase anonymity, players were seated with divisions between them. After the contribution decisions were made the enumerators calculated the group's total contribution and announced the return from the group account. Individuals could record this information.

In the second stage of the punishment treatment, individuals could view the endowments received by all players, as well as their corresponding contribution on a punishment template. Players then had the choice to allocate "fine" points to other players by making entries on this punishment template. Punishment decisions were again anonymous due to

[4]Although a number of studies have used a MPCR of 0.4 and group size of 4 following the the work of Fehr and Gächter (2000), varying designs with group size ranging from 3–10 members and MPCRs ranging from 0.2–0.75 (Bowles et al., 2001, Cinyabuguma et al., 2005, Sefton et al., 2001, Carpenter, forthcoming, and also Anderson and Putterman, 2005), have also been used.

[5]Instructions are available from the authors on request.

the design features described above.

Each punishment or "fine" point received reduced a player's stage I earnings by 5 tokens[6]. Allocating "fine" points was costly, with 1 token being deducted for each point awarded to another player. Individuals within the group did not have access to information about the punishment decisions of other players in the group: each was just given the aggregate number of punishment points allocated to them in each round.

2.5 Field setting and recruitment

Our study focusses on nine rural fishing communities along the West Coast of South Africa. Participants were recruited in a number of ways to minimize the potential for sample selection problems. Both males and females were targeted given that quota has also been allocated to women in the last 5 years. They were contacted through key persons in the community, representatives of fishers groups, posters, and local newspapers. In one larger community we informed parents at a school function[7]. Attrition rates between the survey and the experiments were relatively low.

A survey was executed during June 2004, one and a half months before the experiment. In total, 569 individuals participated in both the survey and experiments, of whom just

[6]Fehr and Gächter (2000) and others following their design use a punishment scale where each point allocated reduces a player's pay-off by 10%. Carpenter (2004b) suggests a simpler punishment design which allows for a constant price of punishment. We use such a design (given low literacy and numeracy rates among our subjects), but receiving punishment is costly and probably at the upper limit of a number of studies that have varied the cost of punishment across treatments (Nikiforakis and Normann (2005), Carpenter (2004), Anderson and Putterman (2005)). Denant-Boemont et al. (2005) use a similar punishment structure to Fehr and Gächter which resulted in reductions in earnings in the range 4.6–16.24%. The reduction in income observed in our study ranges from 39% in equal groups to 24% and 22% for high and low endowment players in unequal groups (on average).

[7]We specified up front that only one person per household was allowed to participate, that participants had to be literate, and that they would receive a show-up fee. There was no way to completely isolate the study from self-selection. However, we tried to schedule the survey on more than one day and at different times of the day, and took into account that active fishers often worked in the morning. While more cooperative persons may have volunteered, the fact that we indicated that each participant would be paid would have been enough incentive to also attract self-interested individuals (Holm and Danielsson, 2005).

over 60% were male. Participants were on average 41 years old and had lived in their communities for most of their lives. Most reported Afrikaans as their home language, so the survey and the experiments were executed in Afrikaans. Educational attainments were low, with 14% of the sample having completed their primary schooling, and 8% having completed high school. Unemployment among participants was high, with only 48% reporting that they were currently employed at the time of the survey[8].

The experimental sessions lasted for 2–3 hours. In some communities two or three sessions were scheduled per day[9]. Each experimental token earned the participant 10 cents (US 2 cents) and on average participants earned about R110 (US22) for the entire experiment. In most cases this translated to about two days' wages.

3 Results of the Experiments

In this section we compare contributions as a fraction of endowment first for equal and unequal groups and then also for low and high endowment players in unequal groups. Thereafter follows our analysis of punishment behaviour for equal and unequal treatments.

3.1 Impact of Punishment on Contributions to the Public Good in Equal and Unequal Treatments

In Figure 1 average contributions as a fraction of endowments (or tokens received) in the VCM and punishment treatments are illustrated, both for players in equal groups (40 ECUs) and for high (50 ECUs) and low (30 ECUs) endowment players in unequal groups.

[8]This level of employment is reflective of prevailing unemployment in these communities.

[9]We control for spill-over effects by randomly allocating sessions as equal or unequal for the public goods experiments. We also test for spill-over effects in the regression analysis that follows.

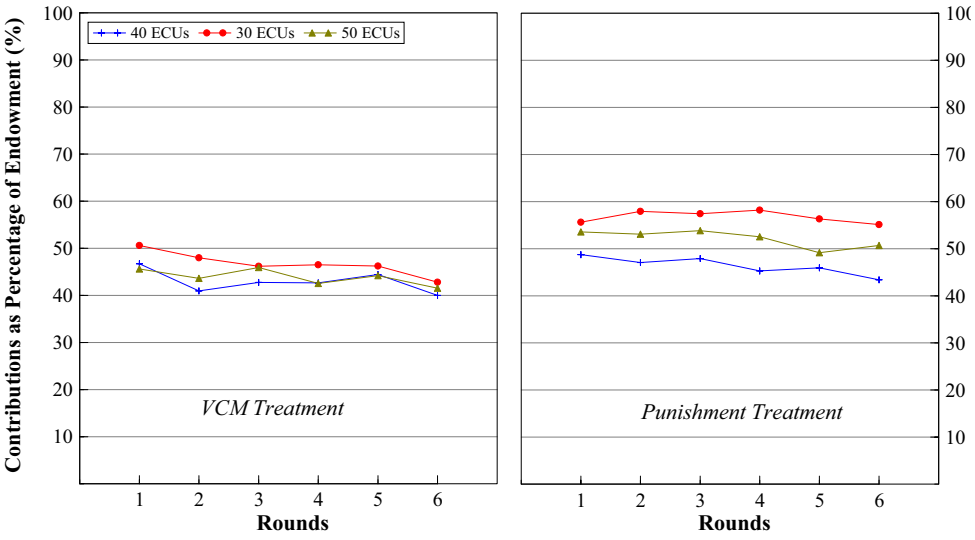


Figure 1: Average fraction of endowment contributed in the VCM and Punishment treatments, for players in equal groups (40 ECUS) and for low endowment (30 ECUs) and high endowment (50 ECUs) players in unequal groups.

> ***RESULT 1****: Punishment is successful in maintaining cooperation in equal and 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). The average increase in contributions between the VCM and punishment treatment is 2.7% for equal groups and 8% for unequal groups.

Average contributions in our punishment treatment are in the range $46 - -57\%$. For other public goods experiments with peer sanctioning contribution levels vary between 40–90%, depending on the cost of punishment (Fehr and Gächter, 2000, Masclet et al., 2003, Anderson and Putterman, 2005). While average contributions in our study are lower than those reported for other artificial field experiments, the increase in contributions between the VCM and Punishment treatment is in line with that described by Carpenter et al. (2004a) for experiments in urban slums in Thailand and Vietnam. They show that social sanctioning increases average contributions in Vietnam by 5% and by 11% in Thailand.

***RESULT 2**: Aggregate contributions in unequal groups is higher on average than in equal groups. This contribution pattern becomes exaggerated once punishment is introduced.*

Average contributions for players in the equal VCM treatment varies from 46.7% to 40% of their token endowment between round 1 and 6. For the unequal treatment contributions are somewhat higher, ranging between 47.45% and 41.98% over the six rounds[10]. In the punishment treatment the gap in contributions between equal and unequal groups is even greater: for equal groups the average contribution starts at 48.76% and declines to 43.4% in the last round, while for unequal groups average contributions range between 55.63% and 55.13%. For both treatments the two-sample Wilcoxon ranksum test confirms that the average fraction of contributions is significantly higher for unequal than for equal groups (VCM: $z = -2.98; p < 0.0029$; Punishment: $z = -8.84; p < 0.0001$).

The estimation results shown in Table 2 for equal and unequal groups (regressions 1 and 3) verify these findings for the punishment treatment[11].

We model the fraction of an individual's endowment contributed to the public account using ordinary least squares (OLS) and multilevel hierarchical modelling (MLHM) techniques[12].

***RESULT 3**: In the punishment treatment, low endowment players in unequal groups contribute a higher share of their endowments than high endowment players on average.*

[10]This is in line with studies that have been performed with students (see Fehr and Schmidt (1999) and Cardenas and Carpenter (2003)), but we do not see the characteristic rapid decline towards full free-riding that marks experiments with students (Davis and Holt, 1993). Similar findings has been made for other studies with non-students (Cardenas and Carpenter, 2003)

[11]Estimation results for the VCM treatment (not reported here) similarly show a significant difference in the average contributions of low and high endowment players.

[12]Multilevel modelling is more appropriate in this context given that it takes into account individual and group level random effects, and also controls for individual nesting within groups (Rabe-Hesketh and Skrondal, 2005). The likelihood ratio tests comparing the linear and MLHM models indicate that the latter is a superior fit in all cases presented here, and we therefore put more confidence in the results obtained using this estimation procedure. All models are specified to include experimental variables and also variables containing socio-economic and self-reported attitudinal information to account for individual level observed heterogeneity.

In both the VCM and Punishment treatments low endowment players contribute a higher share of their endowment towards provision of the public good. In the Punishment treatment this difference between contributions of low and high endowment players is enhanced (see Figure 1). These results are significant according to the two sample Wilcoxon ranksum test for both treatments (VCM: $z = 1.86$; $p < 0.07$, Punishment: $z = 3.43$; $p < 0.0006$). While average contributions for high endowment players are 52.2% of their endowment in the punishment treatment, the average contribution for low endowment players is 56.8%. From the regression results reported in Table 2 it is evident that the average fraction con-

Table 2: Fraction of endowment contributed.

	Punishment treatment (OLS)		Punishment treatment (MLHM)	
	(1)	(2)	(3)	(4)
Dep. var.: Fraction of endowment contributed	Equal & Unequal	Unequal only	Equal & Unequal	Unequal only
Round	-0,01 ***	-0,01 ***	-0,01 ***	-0,01 ***
	(,002)	(,002)	(,001)	(,002)
Unequal treatment (dummy)	0,19 **		0,09 ***	
	(,084)		(,025)	
Player is HIGH		-0,07 ***		-0,06 *
		(,011)		(,032)
Constant	0,50 ***	0,80 ***	0,58 ***	1,00 ***
	(,093)	(,057)	(,082)	(,159)
n	4986	2484	9486	2484
R-squared	0,40	0,45		
Adjusted R-squared	0,38	0,43		
Wald chi2			78	47
Log likelihood			2782 ***	777 ***
LR test vs. linear regression:			7175 ***	1671 ***
Controlling for:				
Community Fixed effects	**Yes**	**Yes**	**Yes**	**Yes**
Group Fixed effexts	**Yes**	**Yes**	**Yes**	**Yes**
Group and Individual Random effects (Nested)	**No**	**No**	**Yes**	**Yes**

Additional controls for age, gender, race, years of education, employment status, self-reported trust in others and participation in voluntary organizations are included in all regressions but not reported here.
Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

tributed by the high endowment players in the punishment treatment is 6–7% less than that of the low endowment players, once we control for other factors. This estimate is significant for both OLS and MLHM model specifications (regressions 2 and 4).

A possible explanation for why low endowment players are observed to make higher relative contributions may be that the potential net gains from cooperation is higher for them. The fixed marginal per capita return (MPCR) from the public good clearly favours 30

token players over 50 token players[13]. Conceding that there may be incentives for strategic behaviour in repeated interaction (Axelrod, 1997; Fehr and Gächter, 2000) lower endowment players may have a greater willingness to signal their intent to commit to cooperative behaviour. For instance, our results for the punishment treatment (Visser, (2006)) indicate that relative net gains realized by low endowment players is significantly higher (10 times) on average than for high endowment players.

Moreover, in the punishment treatment the relative expense suffered by low endowment players from being punished is roughly 1.5 times that which high endowment players incur on average (Relative cost: Low endowment, 13.3/30=0.433; High endowment, 14.6/50=0.292). Fear of punishment may therefore be another factor in explaining the higher relative contributions of low endowment players in the punishment treatment. Both Egas and Riedl (2005) and Nikiforakis and Normann (2005), in testing the effect of altering cost of punishment, indicate that the higher the cost of receiving punishment the more efficient groups are at maintaining cooperation.

3.2 Punishment Behaviour in Equal and Unequal Groups

In this section we investigate the demand for punishment and determinants for punishment in equal and unequal groups. The average number of punishment points allocated by one player to another in equal groups is 1.51, whereas in unequal groups it is 0.91. This is consistent with earlier findings that average contributions in the equal treatment (46%) are lower than in the unequal treatment (55%). The Wilcoxon ranksum test indicates that this difference in punishment allocation is significant ($z = 8.328; p < 0.0001$).

In Table 3 we show the regression results from OLS and MLHM estimation for our pooled sample (where we compare behaviour of equal and unequal treatments) and for unequal groups (where we compare the behaviour of low and high endowment players). Here we estimate punishment awarded to another player, controlling for treatments, characteristics of the punisher and of the player being punished, as well as, the mean contribution fraction by the rest of the group. We also include a number of socio-economic variables that are not

[13]For instance, if no one allocates punishment, full contribution by both low and high endowment players results in returns of 50 (=80-30) ECUs and 30 (=80-50) ECUs respectively.

Table 3: Punishment awarded — all groups.

	OLS Equal&Unequal	OLS Unequal	MLHM Equal&Unequal	MLHM Unequal Only
Dependant Variable : Punishment awarded to other player	(1)	(2)	(3)	(4)
Round	-0,05 **	-0,06 **	-0,06 ***	-0,06 ***
	(,217)	(,027)	(,019)	(,024)
Unequal Treatment	-(2,89) **		-(,035)	
	(1,279)		(,46)	
OTHER PLAYER'S CHARACTERISTICS:				
Other player is HIGH (dummy)		0,22		0,25 *
		(,161)		(,147)
Pos. deviation of other player from group mean share (excl. other player)	-0,63 *	0,90	-0,51 *	1,48
	(,345)	(,627)	(,309)	(,578)
Pos. deviation of other player from group mean share (excl. other player) * Unequal Treatment	0,50		0,411	
	(,533)		(,477)	
Pos. deviation of other player from group mean share (excl. other player) * Punisher is HIGH		-1,70 ***		-1,97 ***
		(,73)		(,665)
Pos. deviation of other player from group mean share (excl. other player) * Other player is HIGH		-0,96		-1,60
		(,703)		(,655)
Abs. neg. deviation of other player from group mean share (excl. other player)	0,97 ***	2,56 ***	1,10 ***	2,88 ***
	(,367)	(,714)	(,329)	(,659)
Abs. neg. deviation of other player from group mean share (excl. other player)* Unequal Treatmen	1,33 **		1,26 **	
	(,56)		(,502)	
Abs. neg. deviation of other player from group mean share (excl. other player) * Punisher is HIGH		-0,87		-1,30 **
		(,76)		(,705)
Abs. neg. deviation of other player from group mean share (excl. other player)* Other player is HIGH		0,10		0,16 ***
		(,752)		(,691)
REST OF GROUP'S CHARACTERISTICS				
Rest-of-group share contributed (excl. punisher)	0,89	0,06	0,18	-0,67 *
	(,635)	(,649)	(,518)	(,655)
Rest-of-group share contributed (excl. punisher) * Unequal Treatment	-1,31		-0,93	
	(,915)		(,741)	
Rest-of-group share contributed (excl. punisher) * Punisher is HIGH		-0,97 *		0,12
		(,599)		(,876)
PUNISHER'S CHARACTERISTICS:				
Punisher is HIGH (dummy)		0,85 **		0,42
		(,387)		(,57)
Pos. deviation of punisher from group mean share (excl. punisher)	0,49	0,77	-0,25	0,29
	(,389)	(,504)	(,374)	(,521)
Pos. deviation of punisher from group mean share (excl. punisher) * Unequal Treatment	-0,36		0,49	
	(,607)		(,597)	
Pos. deviation of punisher from group mean share (excl. punisher) * Punisher is HIGH		-1,29		-0,31
		(,814)		(,814)
Abs. neg. deviation of punisher from group mean share (excl. punisher)	0,58	0,36	0,62	0,53
	(,422)	(,54)	(,427)	(,564)
Abs. neg. deviation of punisher from group mean share (excl. punisher)* Unequal Treatment	-0,14		-0,04	
	(,622)		(,622)	
Abs. neg. deviation of punisher from group mean share (excl. punisher)* Punisher is HIGH		1,25 *		0,33
		(,736)		(,772)
Constant	-5,44 ***	-3,61 ***	0,86	1,82
	(1,04)	(1,05)	(1,09)	(1,38)
Observations	4655	2214	4655	2214
R-squared	0,33	0,42		
Adjusted R-squared	0,31	0,40		
Wald chi2			155	185
Log likelihood			-10659 ***	-4722 ***
LR test vs. linear regression:			1572 ***	654 ***
Community Fixed effects	**Yes**	**Yes**	**Yes**	**Yes**
Group Fixed effexts	**Yes**	**Yes**	**Yes**	**Yes**
Group and Individual Random effects (Nested)	**No**	**No**	**Yes**	**Yes**

Additional controls for age, gender, race, years of education, employment status, self-reported trust in others and participation in voluntary organizations are included in all regressions but not reported here.
Standard errors in parenthesis. *** = 1% significance; ** = 5% significance; * = 10% significance.

reported here. Our results for the pooled OLS model (regression 1) confirm that players in unequal groups assign significantly fewer punishment points to other players, but once we account for individual nesting within groups (regression 3) the result is not significant.

> ***RESULT 4****: Demand for punishment by low endowment and high endowment players is not significantly different, even though the low endowment players face higher relative costs in allocating punishment.*

Notwithstanding the relative cost (which includes the direct cost of assigning punishment points and the possible additional cost of retaliation), the amount of punishment assigned by the high and low endowment players is very similar. The average punishment points allocated per individual to another player for the high endowment players is 0.9 points and for the low endowment players 0.93 points. This difference in demand for punishment is not significant according to the Wilcoxon ranksum test ($z = 0.99; p < 0.322$). Although the estimation results in Table 3 reported for the OLS regressions indicate that high endowment players assign significantly more punishment, this effect is not significant for the MLHM model where we control for individual and group level nesting. As before, the likelihood ratio-test confirms that the results obtained from the MLHM model are more reliable.

Our results contrast those of Anderson and Putterman (2005) and Nikiforakis and Normann (2005), who find that demand for punishment diminishes with the cost. Carpenter (2004) in turn specifically tests income elasticity of demand for punishment within subjects with respect to stage I pay-offs in each round. He finds that demand for punishment is rather income inelastic. Our findings similarly negate strong evidence of an income effect. As mentioned previously, the VCM with fixed MPCR favours low endowment players in terms of relative net gains from cooperation by the group. Low endowment players may therefore have additional incentives to use punishment to discipline free-riders, which exceeds the relative cost of assigning punishment.

> ***RESULT 5****: Free-riding elicits more punishment from unequal groups, with low endowment players punishing both positive and negative deviation from the group mean share more vehemently than high endowment players.*

Figure 3.2 shows average punishment allocated to another player based on that player's positive or negative deviation in contribution from the average group share (excluding that player)[14]. The bar labels indicate the percentage of total deviations represented by

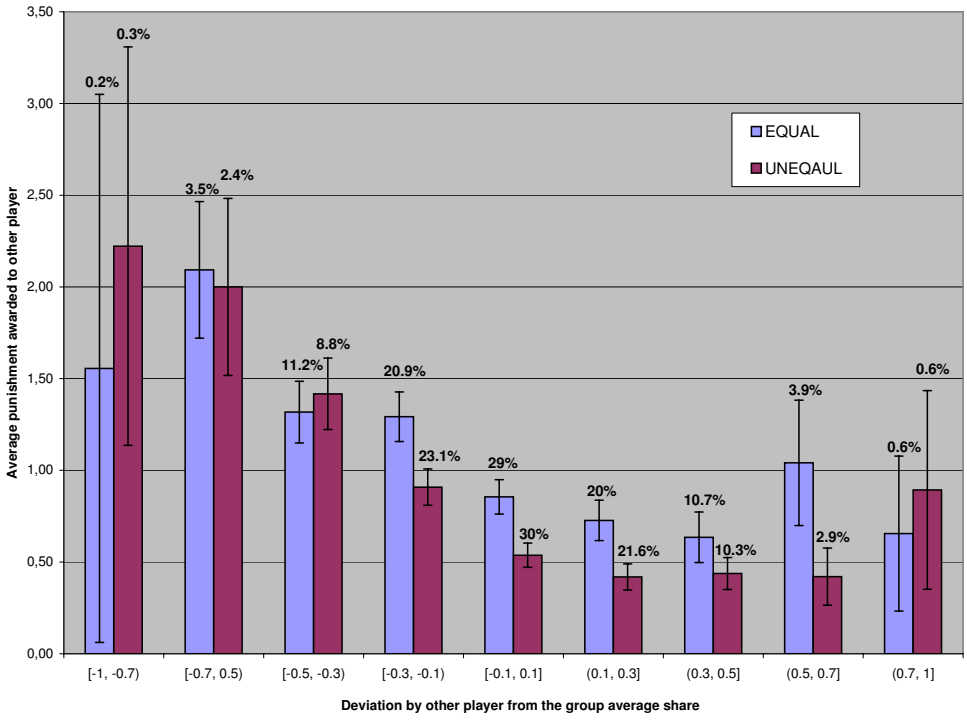


Figure 2: Histogram of punishment allocated: equal versus unequal groups.

the specific category, and error bars give 95% confidence intervals for the reported figures. In both equal and unequal groups, higher levels of punishment are clearly associated with larger negative deviation from the rest of the group share.

In unequal groups negative deviation in the contribution share of the other player from that of the rest of the group elicits significantly more punishment than in equal groups. Low endowment players in contrast punish both those that deviate positively or negatively from the group mean share significantly more than high endowment players (see Table 3, regressions 2 & 4)[15]. These results are robust for all model specifications and are also

[14]In this histogram we exclude punishment allocated by individuals who punish more than 20 points in total per round (which accounts for only 3% of observations and slightly biases the observed effects), given that there is no control for individual fixed effects.

[15]In estimation results not reported here, we find that low endowment players punish their own type

visible in the upper diagram in Figure 3.2, which illustrates punishment allocation for deviation from the group mean share by low and high endowment players. Our results suggests that low endowment players are more responsive to a contribution norm, and that they use punishment as a genuine attempt to coax other players into contributing their fair share (in this case proportional to their endowment).

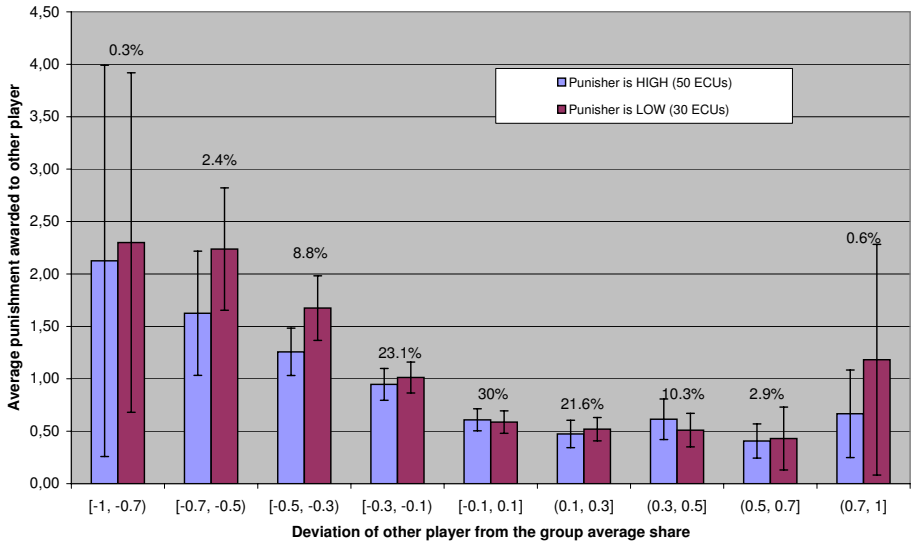
> ***RESULT 6****: Inequality aversion is evident from punishment behaviour aimed purely at differences in endowments, but punishment is also elicited based on the interaction of endowments and contributions.*

Fehr and Smidt (1999) predict that inequality averse players will use punishment to equalize differences in pay-off in a public goods experiment[16]. Punishment is allocated in the second stage after contributions to the public good have been made. The first stage earnings in the punishment treatment are a combination of the endowment individuals received, the level of free riding incurred by the individual, and the contributions made by the rest of the group. Inequality aversion in punishment behaviour may hence be revealed as a response to ex-ante differences in endowment between players, a response to ex-post differences in relative contributions between players, or a response due to ex-post differences in pay-offs between players. For the experimental design we use here, even if players follow a proportional contribution norm, high endowment players still receive a higher pay-off than low endowment players. Divergence from the proportional contribution norm by high endowment players may therefore attract more punishment than divergence by low endowment players.

Our findings indicate that, on average, a high endowment player in an unequal group receives more punishment in total than a low endowment player (0.96 versus 0.86 punishment

significantly more for contributing above the group mean share.

[16]Even in a treatment with equal endowments, punishment behaviour in response to inequality aversion may not correspond with the exact difference in pay-offs between players. Depending on the number of group members, punishers may expect others in the group to punish free-riders as well. At the other extreme Anderson and Putterman (2005) find that individual punishment behaviour sometimes violates Fehr and Schmidt's prediction insofar as individuals will punish another even if the cost of doing so is greater than the loss incurred by the person receiving the punishment. A similar result was obtained by Falk et al. (2001).



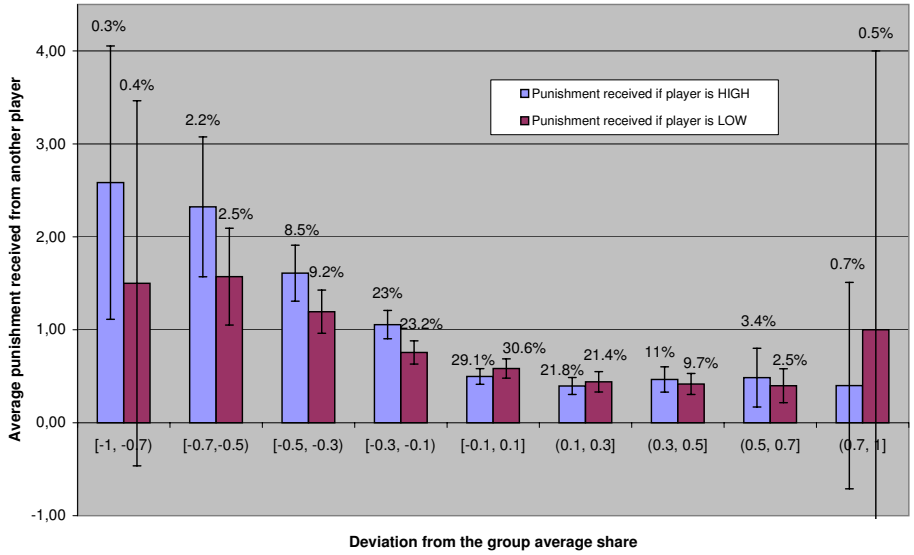


Figure 3: Histograms of punishment allocated and received in unequal groups.

points). The Wilcoxon two-sample ranksum test ($z = -2.527; p < 0.0115$) indicates that there is a significant difference in the punishment received by low and high endowment players. In Table 3 the coefficient obtained for the endowment dummy ("Other player is HIGH") is positive for both OLS and MHLM model specifications (regressions 2 and 4) and in the latter case the estimate is also significant.

We also observe evidence for inequality aversion with respect to players' pay-offs (or alternatively the interaction of endowments and contributions). While all players are punished for free-riding, high endowment players receive more punishment for being below the rest of the group's average contribution share (see lower diagram in Figure 3.2), and this difference is highly significant for our MLHM specification (see regression 4 in Table 3). In contrast, low endowment players are reprimanded for contributing more than the group's average share, but these estimates are not significant.

Overall we see that punishment is generally associated with violation of a contribution norm, which in this case corresponds to each player contributing a proportional share of his or her endowment (Sugden, 1984; Visser and Burns, 2005). Both histograms in Figure 3.2 (indicating punishment allocated and punishment received within unequal groups) clearly show a pattern of punishment within unequal groups similar to that described in studies by Cinyabuguma et al. (2004) and Gächter and Herrmann (2006), where punishment most frequently being received for free-riding (being below the group average share), but perverse punishment of those above the group mean share is also present. The regression results in Table 3 however show that once we control for other variables, such as the contribution share of the punisher, those who contribute a greater share than the rest of the group actually receive significantly less punishment in our pooled sample (regression 1 & 2). In unequal groups (regressions 2 & 4) this effect is positive but not significant.

3.2.1 Welfare implications of inequality and peer punishment

In this section we briefly summarize the welfare outcomes for unequal groups when peer punishment is involved. The welfare effects of punishment in unequal groups are important in understanding the motivation for punishment. Given higher average contributions in unequal groups for the VCM treatment as well as the punishment treatment, aggregate

welfare in terms of final earnings within these groups are higher than for equal groups. Punishment raises contributions, and therefore first stage earnings from the treatment with punishment are higher relative to those in the VCM for all players. However once costs of punishment has been deducted, overall earnings are reduced dramatically (see Table 3.2.

Table 4: Average overall earnings after the VCM and Punishment treatments.

	AVERAGE OVERALL EARNINGS (ECUs)			*AVERAGE OVERALL NET GAIN ON ENDOWMENT (ECUs)*		
	VCM	StageI Punishment (before Punishment)	Final Punishment (after Punishment)	VCM	StageI Punishment (before Punishment)	Final Punishment (after Punishment)
EQUAL	340	345	222	101	109	-14
UNEQUAL	348	370	281	109	130	42
T50	384	402	307	85	102	7
T30	313	337	256	133	157	76

While high endowment players do better in terms of absolute earnings in both the VCM and Punishment treatments, the overall earnings difference in the VCM treatment between low and high endowment players is 27% lower after the punishment treatment than after the VCM treatment. This represents a redistribution of wealth from high to low endowment players. Moreover, in the VCM treatment overall net gains for low endowment players are 1.57 times greater than for high endowment players. Once punishment is introduced, overall net gains for low endowment players are on average 10 times higher than for high endowment players. These findings are discussed in more detail in Visser (2006).

4 Conclusion

The effect of inequality on cooperative and punitive behaviour in the presence of social dilemmas may have important consequences for welfare outcomes of those involved, and also for the management of common resources. In South Africa, one of the most unequal countries in the world, the allocation of fishing quota has introduced additional inequalities within communities, resulting in ongoing strife. We use repeated public goods experiments with equal and unequal treatments, as well as punishment treatments, to study the interaction of inequality and punishment in a controlled environment. In order to preserve

external validity we use a large sample of people from affected communities, given their familiarity with the issues we want study.

As reported by Fehr and Gächter (2000) and Masclet et al. (2003), we find that punishment leads to higher contributions that may be sustained over sequential play. Although we use this experiment to study real life phenomena, this is the first study to our knowledge that combines inequality (in endowments) and punishment in the voluntary contribution mechanism. It may therefore provide insight relevant to public goods experiments in general. Of specific relevance to our research question is that peer punishment as a sanctioning mechanism is used more successfully in unequal than equal groups to increase cooperation.

Our findings for the VCM treatment are in line with a small number of previous experiments conducted in the laboratory which report higher aggregate contributions in unequal settings (Chan et al., 1997, 1999; Buckley and Croson, 2006) and over-contribution by lower endowment participants relative to those with higher endowments (Buckley and Croson, 2006, Cherry et al., 2004). That this effect is exaggerated when punishment is introduced may be attributed to differences in the relative cost of receiving punishment, but also differences in the net gains from group cooperativeness for high and low endowment players.

Interestingly, low endowment players use punishment as frequently, as high endowment players. They are also more strategic in their punishment behaviour, encouraging cooperation, but also ensuring that all group members contribute their fair share (in proportion to their endowment). While they punish free-riding more than high endowment players, they punish their own type more for over-contribution relative to the rest of the group.

Our results shows evidence of inequality aversion in endowments and also in pay-offs (the interaction of endowments and contributions): high endowment players receive more punishment than low endowment players, but high endowment players are also punished significantly more for contributing too little.

These findings suggests that even though individuals may be inequality averse, the relative benefits derived from the public good by the poor are greater than for the rich in unequal groups (hence the observed 'over-contribution' by low endowment players). Incentives to attain social optimum contributions may therefore overshadow preferences for equality in such interactions. However, when sanctioning is available individuals use punishment

discriminately to favour the poor. Over repeated interaction total inequality in pay-offs are reduced in the punishment treatment. Our results suggests that unequal groups are more efficient in coordinating their behaviour, and that the ability to use peer sanctioning in securing the provision of a public good may be to the advantage of the poor in unequal settings.

5 References

Allesina, Alberto and Eliana La Ferrara. "Participation in Heterogeneous Communities." *Quarterly Journal of Economics*, 115(3):847-904, 2000.

Anderson, Lisa R., Jennifer M. Mellor and Jeffrey Milyo. "Inequality and Public Good Provision: An Experimental Analysis." *Working Paper No.12*, College of William and Mary, 2004.

Anderson, Christopher M. and Louis Putterman. "Do Non-strategic Sanctions Obey the Law of Demand? The Demand for Punishment in the Voluntary Contribution Mechanism." *Games and Economic Behaviour*, 2005.

Axelrod, Robert. "Promoting Norms." *Chapter in The Complexity of Cooperation*, Princeton University Press, Princeton, New Jersey, 1997.

Barr, Abigail. "Cooperation and shame." *Center of the Study of African Economics Working Paper*, 2001.

Barr, Abigail. "Trust and expected trustworthiness: experimental evidence from Zimbabwean villages." *The Economic Journal*, 113:614-630, 2003.

Bochet, Olivier, Talbot Page and Louis Putterman. "Communication and Punishment in Voluntary Contribution Experiments. *Journal of Economic Behaviour*, 60(1):11-26, 2006.

Bowles, Samuel and Herbert Gintis. "Social Capital and Community Governance." *The Economic Journal*, 112(483):419-436, 2000.

Bowles, Samuel, Jeffrey Carpenter and Herbert Gintis. "Mutual Monitoring in Teams: Theory and Evidence on the Importance of Residual Claimancy and Reciprocity." *mimeo*, 2001.

Buckley, Edward and Rachel Croson. "Income and Wealth Heterogeneity in the Voluntary Provision of Linear Public Goods." *Journal of Public Economics*, 90(4-5):11-26, 2006.

Cardenas, Juan Camillo, John Strandlund, and Cleve Willis Cochrane. "Economic inequality and burden-sharing in the provision of local environmental quality." *Ecological Economics*, 40:379395, 2002.

Cardenas, Juan Camillo. "Real Wealth and Experimental Cooperation: Experiments in the Field Lab." *Journal of Development Economics*, 70(2):263-289, 2003.

Cardenas, Juan-Camillo and Jeffrey P. Carpenter."Three Themes on Field Experiments and Economic Development." *mimeo.* Middlebury University, 2003.

Carpenter, Jeffrey P., Amrita G. Daniere and Lois M.Takahashi. "Cooperation, trust and social capital in Southeast Asian urban slums." *Journal of Economic Behavior and Organization*, 55: 553-551, 2004a.

Carpenter, Jeffrey P. Peter Matthews and Okomboli Ong'Ong'a "Why Punish? Social

Reciprocity and the Enforcement of Prosocial Norms." *Journal of Evolutionary Economics*, 14(4): 407-429, 2004b.

Carpenter, Jeffrey. "The Demand for punishment." *Journal of Economic Behaviour and Organization*, forthcoming.

Carpenter, Jeffrey P. "Punishing Free-Riders: how group size affects mutual monitoring and the provision of public goods." *Journal of Economic Behavior and Organization*, forthcoming 2006.

Chan, Kenneth S., Stuart Mestelman, Robert Moir and Andrew Muller. "The voluntary provision of public goods under varying income distributions." *Canadian Journal of Economics*, 29(1):54-69, 1993.

Chan, Kenneth S., Rob Godby, Stuart Mestelman, and R. Andrew Muller. "Equity Theory and the Voluntary Provision of Public Goods." *Journal of Economic Behaviour and Organization*, 32(3):349-364, 1997.

Chan, Kenneth S., Stuart Mestelman, Rob Moir, and R. Andrew Muller. "Heterogeneity and the Voluntary Provision of Public Goods." *Experimental Economics*, 2(1):5-30, 1999.

Cherry, Todd L., Stepan Kroll and Jason F. Shogren. "The Impact of Endowment Heterogeneity and Origin on Public Good Contributions: Evidence from the Lab" *Journal of Economic Behavior and Organization*, 57(3):357-365, 2004.

Cinyabuguma, Matthias, Talbot Page, and Louis Putterman. "Cooperation under the threat of expulsion in a public goods experiment." *Journal of Public Economics*, 89:1421-1435, 2005.

Cinyabuguma, Matthias, Talbot Page, and Louis Putterman. "On Perverse and Second-order Punishment in Public Goods Experiments with Decentralized Sanctioning." *mimeo*, Brown university, 2004.

Davis, Douglas D., and Charles A. Holt.*Experimental Economics.* Princeton University Press, Princeton. 1993.

Denant-Boemont, Laurent, David Masclet and Charles Noussair. "Punishment, Counter-punishment and Sanction Enforcement in and Social Dilemma Experiment." *mimeo*, 2005.

Egas, Martijn and Arno Riedl. "The Economics of Altruistic Punishment and the Demise of Cooperation." *mimeo*, 2005.

Falk, Armin, Ehrnst Fehr and Urs Fischbacher."Driving Forces of Informal Sanctions." *Econometrica*, forthcoming.

Fehr, Ernst and Simon Gächter. "Cooperation and Punishment in Public Goods Experiments." *American Economic Review*, 90(4):980-994, 2000.

Fehr, Ernst. and Klaus M. Smidt. "A Theory of Fairness, Competition and Cooperation." *Quarterly Journal of Economics*, 114(3):817-68, 1999.

Gächter, Simon and Benedikt Herrmann. "The limits of self-governance in the presence of spite: Experimental evidence from urban and rural Russia." *CeDEx Discussion Paper*, No. 2006-13, 2006.

Hacket, S., E. Schlager and J. Walker. "The Role of Communication in Resolving Commons Dilemmas: Experimental Evidence with Heterogeneous Appropriators." *Journal of*

Environmental Economics and Management, 27:99-126, 1994.

Harrison, Glenn W. and John A. List. "Field Experiments." *Journal of Economic Literature*, XLII:1009-1055, 2004.

Holm, Hakan J. and Anders Danielsson. "Tropic trust vs Nordic Trust: Experimental evidence from Tanzania and Sweden." *The Economic Journal*, 115(503):532-505.

Isaacs, Moenieba, Mafanisa Hara and Jesper Raakjaer. "South African Fisheries Reform: Past, Present and Future?" *Policy Brief* 16, PLAAS, 2005.

Masclet, David, Charles Noussair, Steven Tucker and Marie-Claire Villeval. "Monetary and Nonmonetary Punishment in the Voluntary Contributions Mechanism." *American Economic Review*, 93:1:366-280, 2003.

Nikiforakis, Nikos. "Punishment and Counter-punishment in Public Good Games: Can we still govern ourselves?" *mimeo*, Royal Holloway, University of London, 2005.

Nikiforakis, Nikos and Hans-Theo Normann. "A Comparative Statics Analysis of Punishment in Public-Good Experiments." *Discussion Papers in Economics*, 05/07 Royal Holloway, University of London, Department of Economics, 2005.

Noussair, Charles, and Steven Tucker. "Combining Monetary and Social Sanctions to promote cooperation." *Economic Inquiry*, 43:649-660.

O'Roirdan, Brian." Fishing Quotas: A New Apartheid?" *SUMUDRA*, 24:9-15, ICSF, 1999.

Rabe-Hesketh Sophia and Anders Skrondal. "Multilevel and Longitudinal Modeling Using Stata." Statapress, Texas, 2005.

Sefton, Martin, Robert Shupp and James Walker. "The effect of Rewards and Sanctions in Provision of Public Goods." *CeDEx Discussion Paper*, 2001.

Sugden, Robert. "Reciprocity: The Supply of Public Goods Through Voluntary Contributions." *The Economic Journal*, 94: 772-787, 1984.

Tyran, Jean-Robert, and Lars P. Feld. "Achieving Compliance when Legal Sanctions are Non-Deterrent." *mimeo*, University of Copenhagen, 2004.

Van Soest, Daan and Jana Vyrastekova. "Economic Ties and Social dilemmas: an experimental study." *CentER Discussion Paper*, 55, Tillburg University. 2004.

Visser, Martine. "Welfare Implications of Peer Punishment in Unequal Societies." *mimeo* Gothenburg University. 2006.

Visser, Martine and Justine Burns. "Fairness Norms in the Provision of Public Goods amongst Non-University subjects from South Africa." *mimeo*, Gothenburg University. 2005.

Walker, James, Roy Gardner and Eleanor Ostrom. "Rent Dissipation in a limited-access common-pool resource: Experimental Evidence." *Journal and Environmental Economics and Management*, 19:203-211, 1990.

Whiteford, A. and Dirk-Ernst van Seventer. "South Africa's income distribution in the 1990s." *Studies in Economics and Econometrics*, 24(3): 7-30, 2000.

United Nations Development Programme (UNDP). "Inequality and Human Development." *Human*

Development Report, Chapter 2:51-71, 2005.