CentER

Discussion Paper

No. 2004–55

ECONOMIC TIES AND SOCIAL DILEMMAS: AN EXPERIMENTAL STUDY

By D.P. van Soest, J. Vyrastekova

June 2004

ISSN 0924-7815

TILBURG UNIVERSITY

Economic ties and social dilemmas: An experimental study*

Daan van Soest[1] and Jana Vyrastekova[1,2]

[1]Tilburg University, Department of Economics and CentER, Tilburg, The Netherlands.
[2]University of Amsterdam, Center for Research in Experimental Economics and Political Decision-Making, Amsterdam, The Netherlands.

May 17, 2004

Abstract

Agents who are tied in a social dilemma situation, oftentimes also engage in other economic activities that require (bilateral) cooperation. We develop an economic experiment to test whether the threat of being excluded from the benefits of cooperation in such an alternative economic activity can be an effective mechanism to deter free-riding in the social dilemma situation. Modelling the former as a gift-giving game and the latter as a common pool game, we find that indeed resource extraction is closer to the socially optimal level if subjects interact with the same individuals in both activities, than if they do not. In addition, we find that sanctioning by means of exclusion is more effective the more profitable the alternative activity.

JEL Classification: C72, C92, D74.
Key words: common-pool resources, peer enforcement, selective exclusion, experiment.

*The authors gratefully acknowledge the European Union's financial support via the Fifth European Framework's BIOECON project, and Jana Vyrastekova is grateful to the Netherlands Organisation for Scientific Research (NWO) for financial support in the form of a VENI grant. We thank Simon Gächter, Eline van der Heijden, Wieland Müller, Jan Potters, Karim Sadrieh, Martin Sefton and Cees Withagen, and participants of the BIOECON workshop on "Contract mechanisms for biodiversity conservation" (Montpellier, May 22-25, 2003) as well as those at seminars at University of Amsterdam, CREED and at the University of Namur for useful comments on an earlier version of this paper. Please send all comments to Jana Vyrastekova, Tilburg University, Department of Economics, P.O. Box 90153, 5000 LE Tilburg, The Netherlands. Tel: +31-13-466 3077, Fax: +31-13-466 3066, E–mail: J.Vyrastekova@uvt.nl.

1 Introduction

Social dilemmas are very common in everyday life. But although self-interested economic agents are expected to pursue their own private interests at the expense of those of the group as a whole, the real world is often not as dire as economic theory predicts. Even in the absence of formal intervention, people are observed to exert effort in fulfilling team tasks (e.g., in the workplace), or to mitigate negative consequences of their actions for the welfare of others.

In economic experiments, spontaneous emergence of cooperation in social dilemmas has been shown to arise if individuals can impose pecuniary sanctions on free riders. Reciprocal individuals are willing to punish those who violate a social norm even if they themselves incur costs when doing so (e.g., Fehr and Gächter [8], Ostrom et al. [15]). And indeed there is evidence that self-regulation by means of pecuniary punishments occurs in the real world. For example, Brazilian fishermen in the Bahia region destroy the nets of fellow fishermen who do not respect the catch quotas (Cordell and McKean [5]).

However, whereas instances of self-regulation by means of pecuniary punishment are known, everyday experience suggests that they are not very common. Ordinary citizens do not usually have the right to destroy another person's property, nor do they have the authority to impose fines; it is the government that has, in most societies, the exclusive right of coercion. What citizens can do, however, is to cease interaction with individuals who free ride in the social dilemma situation, and refuse to cooperate with them in *other* social or economic circumstances in which they meet. Indeed, most behavior is closely embedded in systems of interpersonal relations (Granovetter [11]), and social dilemmas often occur in communities which are, by definition, characterized by the presence of multiple forms of interaction that require cooperation by two or more individuals (cf. Bowles and Gintis [4]). Ceasing cooperation in these other activities may be used as a sanctioning device to discipline behavior of one's peers in the social dilemma situation. For example, Japanese villagers, Irish fishermen, and inhabitants of the Solomon Islands have in common that they cut contact with fellow villagers who free ride with respect to fishing, thus denying them the benefits of cooperation in other economic activities

(McKean [14], Taylor [17], and Hviding and Baines [12]).

In this paper, we present experimental evidence on the behavior of participants in a social dilemma situation (represented by a Common Pool Resource game) who also interact in an additional economic activity which requires bilateral cooperation (a two-sided gift-giving game). We test whether thus embedding the social dilemma in a wider economic (or social) environment sheds light on the emergence of cooperation. We hypothesize that linking the Common Pool Resource (CPR) game and the gift-giving game affects behavior in the former as we expect subjects to unilaterally cease cooperation in the gift-giving game in order to discipline the behavior of others in the CPR game. We expect this sanctioning device to occur naturally in our experiment, and will refer to it as the selective exclusion mechanism.[1] If indeed selective exclusion occurs naturally, we can conclude that communities are better at solving social dilemmas than otherwise unconnected groups of individuals. Modelling the social dilemma situation in the form of a CPR game provides a strong challenge to this self-regulatory mechanism as cooperation in CPR games, if any, usually unravels fast (Ostrom et al. [15], Vyrastekova and van Soest [18]).

The design of our experiment is as follows. Subjects participate in a finitely repeated game. Each round consists of a stage game of two separate games that are played sequentially, the CPR game and the gift-giving game. The repeated game has only one subgame perfect Nash equilibrium: rational money-maximizing individuals always overharvest the CPR and never give a gift to any other individual. This prediction is independent of whether individuals interact with the same group of individuals in both constituent games, or not. However, the presence of reciprocal individuals invalidates this prediction as these subjects may be willing to engage in gift exchange. Then, aggregate efficiency of CPR use may be higher if they interact with the same group of individuals in both activities (the Linked treatment), than if they do not (the Unlinked treatment). Individuals in the Linked treatment have the option to refuse to give gifts to those who overharvest the CPR, whereas there is no such possibility in the Unlinked treatment. By comparing these

[1] Note that selective exclusion is with respect to (voluntary) cooperation in the alternative economic activity; it does not refer to denying individuals the right of access to the resource, as this is very often not legal/feasible in practice (McCarthy et al. [13]).

two treatments, we can assess the viability of the selective exclusion mechanism and its effect on the efficiency of CPR use.

In some respects, the exclusion mechanism we study is similar to the pecuniary punishment mechanism. The most important similarity is that in order to be effective, both mechanisms require the presence of reciprocal individuals. In the latter mechanism, this is because it is not only costly to receive sanctions, it is also costly to impose them. That means that a subject imposing punishments actually provides a public good, and the Nash equilibrium prediction when all agents are assumed to be pure money maximizers, is that sanctioning will never take place. A similar line of reasoning holds for the selective exclusion mechanism, which requires the presence of reciprocal individuals to have a positive number of gifts being distributed; in the absence of gift-giving, there is no means to sanction other individuals' behavior either.

But selective exclusion differs from pecuniary punishment in two major respects. First, consistent with reality, we assume that giving gifts is costly. That means that the decision maker is *saving* money when deciding to sanction a free rider by refusing to give a gift, whereas sanctioning is costly in the pecuniary punishment mechanism. Second, pecuniary punishment is instantaneous and is not likely to be maintained over multiple periods unless the person punished persists in acting non-cooperatively with respect to CPR extraction. However, in our exclusion mechanism, trust does play a role and hence violating it may have persistent effects. If mutually beneficial cooperation in the gift-giving game is severed because one individual sanctions non-cooperative extraction behavior by the other, it may be difficult to re-establish the gift-giving relationship later on, and this is likely to provide a larger threat the more profitable gifts are. These two characteristics suggest that self-regulation by means of selective exclusion is expected to be very effective in inducing cooperative behavior, as is, for that matter, the pecuniary punishment institution (e.g. Andreoni and Miller [1], Fehr and Gächter [8], Ostrom et al. [15] and [16]).

However, the idea that peer enforcement by means of ceasing cooperation occurs naturally within a community is not self-evident, and neither is the statement with respect to the impact of profitability of gift exchange. Sanctioning (by refusing to give gifts) can still be costly if the punished individual either views the other person's refusal to give gifts as being unfair, or tries to deter future sanctioning. In these cases, the punished individual may retaliate and refuse to give gifts to the 'punisher' in the next period, and cooperation in the gift-giving game may unravel. That means that potential norm enforcers may choose to refrain from imposing the sanction in order not to jeopardize the gift-giving relationship. From this perspective, punishing free riders in the social dilemma is a public good, as is the case in the pecuniary punishment experiments. In this light, it may actually be the case that ceasing cooperation is *less* likely to occur the more profitable is the alternative activity, because individuals are less willing to risk jeopardizing lucrative gift exchange opportunities to obtain relatively small efficiency gains in the social dilemma.

Thus, it depends on (the beliefs of others about) each subject's response to others' ceasing cooperation whether (i) peer enforcement actually occurs in our experiment, (ii) the community treatment (the Linked treatment) outperforms the disjoint group experiment (the Unlinked treatment) in terms of efficiency of CPR use, and (iii) CPR efficiency is higher the more profitable the gift-giving game. We sort out these arguments by constructing a 2x2 design, the treatment variables being linking (whether or not the two constituent games are played with the same group of individuals), and the costs of providing gifts (which can be either high or low).

The remainder of the paper is organized as follows. In section 2 we present the model, formulate the standard game theoretic predictions as well as our behavioral hypotheses, and briefly discuss the relevant details of the experiment's design. The data are analyzed in sections 3 and 4, and section 5 concludes.

2 The model, experiment design and hypotheses

2.1 The model

The basis of our experiment is a finitely repeated stage game, Γ^{CG}. In each round of this stage game, two games are played sequentially, a standard static Common Pool Resource game (cf. Ostrom et al. [15]) and a two-sided version of the standard gift-giving game (cf. Berg et al. [3]), which will be referred to with Γ^C and Γ^G, respectively. The novelty of our design is that rather than studying the constituent games Γ^C and Γ^G in isolation, we explore the consequences of linking the two.

The number of periods the stage game Γ^{CG} is played, T, is known to all experiment participants. Each participant plays both games in a group of N players, but the group of players in game Γ^C, denoted A^C, is not necessarily the same as the group in game Γ^G, denoted A^G. Differences in group composition is, in fact, a treatment variable, as is the relative profitability of games Γ^C and Γ^G.

First, let us consider game Γ^C. In each period, all N individuals must divide a fixed endowment of effort, e, between CPR extraction and an alternative employment (the outside option). Extraction effort exerted by user i in period t is denoted $x_{i,t}$, and hence subject i's effort devoted to the outside option is $(e - x_{i,t})$. The outside option yields a fixed per-unit wage rate, w. When extracting, the individual agents incur costs that are linear in extraction effort; marginal cost are constant and equal to v. The group's revenues in period t, R_t, depend on the aggregate amount of extraction effort in that period, $X_t = \sum_{i=1}^{N} x_{i,t} \left(i \in A^C\right)$ according to the function $R(X_t) = AX_t - BX_t^2$. User i's share in these revenues is proportional to his/her share in aggregate extraction effort $(x_{i,t}/X_t)$. Hence, subject i's payoff in game Γ^C in period t equals:

$$\pi_{i,t}^C(x_{i,t}, X_t) = w\left[e - x_{i,t}\right] + \frac{x_{i,t}}{X_t}\left[AX_t - BX_t^2\right] - vx_{i,t}, \tag{1}$$

with $A - v - w > 0$.

The socially optimal extraction effort level in game Γ^C is the one that maximizes the unweighted sum of the N group members' payoffs as defined in (1). Transfers are not feasible and all subjects are homogenous. Therefore, the equitable socially optimal extraction effort level is $x^* = (A - v - w)/2NB$.

Assuming that subjects are rational and aim to maximize their own payoffs, user i's best response function can be determined by maximizing (1) with respect to $x_{i,t}$ while taking the aggregate extraction effort by all others $(X_{-i,t} = \sum_{j \neq i} x_{j,t};\ i, j \in A^C)$ as given. Then, user i's best response function is $x_{i,t}(X_{-i,t}) = (A - v - w)/2B - X_{-i,t}/2$, and hence the unique symmetric Nash equilibrium extraction effort equals $x^{NE} = (A - v - w)/2(N+1)$. Because $x^{NE} > x^*$ if $N > 1$, the CPR game poses a social dilemma.

In the two-sided simultaneous gift-giving game Γ^G, each subject makes $N-1$ binary choices whether to give a gift to each of his/her $N-1$ fellow group members, or not.

Let $p_{ij,t} = 1$ ($p_{ij,t} = 0$) denote that individual i gives (does not give) a gift to individual j ($j \neq i$; $i, j \in A^G$) in period t. Giving gifts is costly to the person providing the gift, and it yields benefits to the gift recipient only. The costs of giving a gift to an additional subject are constant and equal to c ($c > 0$), and hence the total gift-giving costs in period t incurred by individual i are equal to $c \sum_{j \neq i} p_{ij,t}$. Individual i's benefits in the gift-giving game, b, are increasing and concave in the number of gifts received $\left(b(\sum_{j \neq i} p_{ji,t}); b'(.) > 0, b''(.) < 0 \right)$. Individual i's payoff in the game Γ^G in period t thus equals:

$$\pi_{i,t}^G \left(\sum_{j \neq i} p_{ij,t}, \sum_{j \neq i} p_{ji,t} \right) = b \left(\sum_{j \neq i} p_{ji,t} \right) - c \sum_{j \neq i} p_{ij,t} \tag{2}$$

We assume that $b(0) = 0$ and impose that the gift-giving activity is efficiency-improving over the whole range of feasible gifts, $b'(.) \geq c$. In addition, we assume that $(N-1)c < b(1)$. This assumption selects a class of gift-giving games where it is relatively cheap to search for a partner: if one gives a gift to each of the $N-1$ other group members in a particular round, the net payoff is positive if one receives a gift from at least one of them in that round.

Social welfare maximization in the gift-giving game implies maximizing the unweighted sum of the individual payoffs as defined in (2). Because $b'(.) \geq c$, social welfare is maximized if each individual sends a gift to all other members of the group, that is if $p_{ij}^* = 1$ for all $i, j \in A^G, i \neq j$. Denoting the socially optimal number of gifts exchanged by P^*, we have $P^* = \sum_{i=1}^N \sum_{j \neq i} p_{ij}^* = N(N-1)$. However, a pay-off maximizing individual acknowledges that giving gifts is costly and yields no direct benefit. Hence, the unique Nash equilibrium of this constituent game is that no gifts are being exchanged: $p_{ij}^{NE} = 0$ for all $i, j \in A^G, i \neq j$.

The order of moves and information is as follows. In each round t, game Γ^C is played first. Each player $i \in A^C$ chooses her extraction effort $x_{i,t} \in [0, e]$. Then, the players in the group A^C are informed about the extraction effort decisions of the $N-1$ other participants in the CPR game ($x_{j,t}$; $j \neq i, i, j \in A^C$) and the resulting payoff $\pi_{i,t}^C$ for all $i \in A^C$. Next, each player participates in the gift-giving game, and again interacts with $N-1$ other players, referred to as group A^G, who may or may not be the same individuals she has interacted with in game Γ^C. Each player i chooses $p_{ij,t} \in \{0, 1\}$ for all

Variable	Description	Game	Value
N	number of individuals per group	Γ^C, Γ^G	5
T	number of rounds of the stage game	Γ^{CG}	25
e	effort endowment	Γ^C	13
w	wage per unit of effort allocated to the outside option	Γ^C	0.5
A	parameter of the resource revenue function	Γ^C	11.5
B	parameter of the resource revenue function	Γ^C	0.15
v	per unit cost of effort in resource extraction	Γ^C	2
c	per unit cost of gifts	Γ^G	2 or 4
$b(0)$	benefits of receiving a gift from 0 individuals	Γ^G	0
$b(1)$	benefits of receiving a gift from 1 individual	Γ^G	20
$b(2)$	benefits of receiving a gift from 2 individuals	Γ^G	30
$b(3)$	benefits of receiving a gift from 3 individuals	Γ^G	36
$b(4)$	benefits of receiving a gift from 4 individuals	Γ^G	40

Table 1: Experiment parameterization

$j \neq i$ ($i, j \in A^G$). Then he/she is informed about whether he/she received a gift of each of the other players in group A^G ($p_{ji,t}$; $j \neq i$, $i, j \in A^G$) as well as about the net payoff (π_{it}^G) obtained by each individual in group A^G. The parameter values that were used in the experiment are presented in table 1, and the associated unique Nash equilibria and social optima are presented in table 2.

2.2 The four treatments

We implement the experiment using a 2x2 design. One design variable is whether individuals interact with the *same* group of individuals in both the CPR and gift-giving games *and* are able to monitor their fellow group members' actions in *both* games (the Linked treatments), or not (the Unlinked treatments). This is implemented as follows. In the Linked treatments $A^C = A^G$, and each individual group member is assigned a unique identifier which is announced together with each action this individual takes in both games. In the Unlinked treatments, $A^C \neq A^G$. However, as actual lab space does not permit us to impose $\left|A^C \cap A^G\right| = 0$ (in fact, we could only impose that $\left|A^C \cap A^G\right| \leq 2$), each individual participant i is assigned two identifiers, one to identify him/her in the CPR game (i^C), and one to identify him/her in the gift-giving game (i^G) ($i^C \neq i^G$).

The second design variable is the cost of giving a gift, which is either high ($c = 4$, in the High cost treatments) or low ($c = 2$, in the Low cost treatments) and hence affects

Variable	Description	Game	Value
x^*	symmetric socially optimal individual extraction effort	Γ^C	6
X^*	socially optimal group extraction effort	Γ^C	30
x^{NE}	symmetric Nash equilibrium individual extraction effort	Γ^C	10
X^{NE}	aggregate Nash equilibrium extraction effort	Γ^C	50
p^*_{ij}	socially optimal gift-giving decision	Γ^G	1
P^*	socially optimal number of gifts per group	Γ^G	20
p^{NE}_{ij}	Nash equilibrium gift-giving decision	Γ^G	0
P^{NE}	Nash equilibrium number of gifts per group	Γ^G	0
$\pi^{C,*}$	symmetric socially optimal payoff to CPR use	Γ^C	33.5
$\pi^{C,NE}$	symmetric Nash equilibrium payoff to CPR use	Γ^C	21.5
$\pi^{G,*}$	individual socially optimal payoff to receiving a gifts if $c = 2$	Γ^G	32
$\pi^{G,*}$	individual socially optimal payoff to receiving gifts if $c = 4$	Γ^G	24
$\pi^{G,NE}$	Nash equilibrium payoff to receiving gifts	Γ^G	0

Table 2: Socially optimal and Nash equilibrium levels of all variables of the stage game.

the relative profitability of the CPR and gift-giving games.

2.3 Hypotheses

Assuming that subjects behave as own payoff maximizing individuals, the stage game Γ^{CG} has a unique subgame perfect Nash equilibrium in all four treatments. Because the game is repeated a finite number of times, backward induction dictates that the Nash equilibria of the constituent games described above will apply in each single round of the repeated game. This is summarized in the following hypothesis:

Standard hypothesis Subjects behave as rational, own payoff-maximizing players, and expect that others are also motivated exclusively by own material payoffs. They apply backward induction. Because the stage game consisting of the common pool game and the gift-giving game is repeated a finite number of times,

- they choose extraction effort level x^{NE} and give no gifts in all rounds of *both* the Linked and Unlinked treatments;
- the resulting efficiency in the CPR game as well as in the gift-giving game is equally low in both treatments; and
- the above predictions are independent of the costs of giving gifts.

Therefore, the standard hypotheses predicts that $x_{i,t} = x^{NE}$ and $p_{ij,t} = 0$ for all $i = 1, .., N, i \neq j$ in all rounds of the experiment, and hence each individual's payoff is expected to be equal to $\pi_i^{NE} = \pi_i^C(x^{NE}, (N-1)x^{NE}) + \pi_i^H(0,0) = \pi_i^C(x^{NE}, (N-1)x^{NE})$ in all rounds of the experiment.

However, money maximization may not be an accurate description of individual preferences. Indeed, previous experiments suggest that a substantial part of mankind has reciprocal preferences (for a recent overview, see Fehr and Gächter [7]). When making decisions, a reciprocal individual chooses actions that increase (decrease) the payoffs of those who choose actions that increase (decrease) his/her payoff. Theory predicts that the presence of reciprocal individuals in the subject pool can have a crucial influence on how the CPR game is played; see Falk et al. [6]. Let us address how the presence of reciprocal individuals might make a difference in the finitely repeated game consisting of the common pool game and the gift-giving game.

First, consider the Unlinked treatment. Reciprocal individuals give a gift to any subject from whom they expect to receive a gift. When they receive a gift in one period they will send one back in the next. However, it is not just the truly reciprocal individuals who will return the gift; strategic money maximizers may do the same. Strategic money maximizers realize that establishing a gift-giving relationship is highly profitable in the medium run, but also that defection yields one-shot benefits. Therefore, they may choose to imitate the reciprocal individuals' behavior in all but the last round, thus building a reputation for being cooperative (see Andreoni and Miller [1]).

Therefore, from the three types considered here, only pure money maximizers who apply backward induction and do not consider the possibility of the presence of reciprocal individuals refuse to give gifts. Recall also that in the gift-giving game, we impose that the benefits of receiving one gift are strictly larger than the total costs incurred when giving a gift to each of the $N-1$ other group members ($b(1) > c[N-1]$). Therefore, even though a subject does not know the preferences of his/her group members, it is sufficient if he/she believes that there is at least one other reciprocal individual in the group to expect a strictly positive payoff from 'testing the water' by sending a gift to all other group members in the first period of the game. So, initiating gift exchange is facilitated as it is profitable even under considerable (initial) uncertainty about others' preferences. That means that in our experiment, bilateral gift exchange is likely to arise among reciprocal individuals and strategic money maximizers who are not too pessimistic about the presence of other reciprocators in the group.

Whereas the gift-giving game allows for direct bilateral reciprocity, the CPR game does not; each individual can choose only one extraction effort level in each round. This is why pure money maximizers have a crucial impact on how the CPR game evolves (see also Falk et al. [6]). Suppose that group A^C consists of $N-1$ reciprocal individuals, and one pure money maximizer. The reciprocal individuals start off selecting the socially optimal extraction effort level, and the pure money maximizer calculates his/her best-response level. Hence the pure money maximizer's payoff is larger than that of the reciprocal individuals. The only way reciprocal individuals can sanction the pure money maximizer's behavior is by increasing their extraction effort; they may behave even more aggressively than the pure money maximizer to force him/her to reduce his/her extraction effort. However, as soon as the reciprocal individuals reduce their extraction effort towards the socially optimal level, the pure money maximizer's best response is to again increase his/her extraction effort. The only equilibrium extraction level is the Nash equilibrium level, x^{NE}.

That means that our alternative hypothesis, which takes into account the presence of reciprocal individuals, is still dire with respect to the CPR game in the Unlinked treatment. However, in the Linked treatment, there is scope for bilateral reciprocity across the two games. Here, the decision whether or not to give a gift to another individual may not only depend on whether one expects that individual to give a gift in return, but also on that individual's extraction behavior in the CPR game. In other words, free-riding in the social dilemma situation can be punished by withholding gifts in the gift-giving game. If receiving gifts is sufficiently profitable, the threat of not receiving gifts may deter free-riding in the CPR game.

How seriously the threat of being sanctioned actually is, may depend on whether the costs of providing a gift are high, or low. Higher costs of providing gifts imply a larger direct cost saving when imposing a sanction (by withholding a gift). But higher costs also imply that the expected benefits from sending a gift falls, and hence we expect lower incidences of gift exchange. This, in turn, dilutes the incentives for the strategic money-maximizers to imitate the reciprocators, and, in addition, obscures the connection between own extraction behavior and the number of gifts received. Is a fall in the number of gifts received a sanction on past excessive extraction behavior, or is it just that other players strategically defect? The reduced clarity of the motivation behind withholding gifts may decrease a sanctioned individual's willingness to incur costs to maintain the gift-exchange relationship, both in terms of reducing extraction effort as well in terms of continuing sending gifts to others. Therefore, we expect that higher costs of sending a gift result in both lower efficiency in the gift-giving game (in both treatments) and lower efficiency in the CPR game (in the Linked treatment only).

Based on the above discussion, our alternative hypothesis accounting for the reciprocal individuals present (and expected to be present) in the subject pool is as follows:

Reciprocity hypothesis: Reciprocal individuals are present and/or believed to be present in the subject pool. Therefore,

- the efficiency of the CPR use is weakly higher than predicted by the Standard hypothesis in the Linked treatment, but equal to the level it predicts in the Unlinked treatment;
- gifts are given both in the Linked and in the Unlinked treatment, resulting in higher efficiency than predicted by the Standard hypothesis;
- the higher the cost of giving a gift, the lower the efficiency in the gift-giving game in both the Linked and Unlinked treatments;
- the higher the cost of giving a gift, the lower the efficiency in the CPR game in the Linked treatment.

Thus, the possibility to condition one's behavior in the gift-giving game on the behavior of others in the CPR game may improve efficiency in the CPR game above the Nash equilibrium prediction in the Linked treatment. The costs of gift-giving affect the extent to which the Linked treatment's efficiency of CPR use exceeds that of the Unlinked treatment.

2.4 Experimental design

In the Spring semester of 2003, we ran eight experimental sessions at Tilburg University, the Netherlands. For each of the four treatments, we collected data on individual behavior in 8 groups of 5 subjects. In total, 160 subjects participated, and they were students in economics, law, or business. The language of the experiments was English; all instructions were read aloud by the experimenters.[2] The experiments were fully computerized; the software was programmed using z-Tree (Fischbacher [9]).

All decisions in the experiment were formulated in a neutral language. We referred to the stage game as 'performing two tasks'. The 'first task' represents the CPR game, and was framed as the decision how to divide an endowment of 13 hypothetical experimental units called tokens between two options, one in which one's payoff (measured in points) depends on one's own decision as well as on the decisions of the other group members (i.e., the extraction from common pool) and the other in which one's payoff depends purely on one's own decision. We explicitly pointed out the symmetric socially optimal extraction level to allow the subjects to focus on the social dilemma aspect of the game rather than on searching for the social optimum.[3] To assist participants in making their decisions with respect to the allocation of tokens, we provided them with a payoff table. The gift-giving game was referred to as the 'second task', and was framed as the decision whether or not to send a fixed number of points (subtracted from the subject's cumulative earnings) to each of the other participants in the group. The history of each of the two games (extraction effort and gift-giving decisions of the fellow participants the subject interacts with) was available on the computer screen. The experiment lasted about 2 hours, and participants earned on average 19.30 Euro (including 5 Euro participation fee).[4]

[2] All instructions, computer screenshots, and the software are available upon request.

[3] The relevant part of the instructions reads as follows: "We would like to draw your attention to the fact that as a group, you and the other group members as a group can earn the maximum number of points if each group member puts 6 tokens in option 1. Note, however, that if every other group member puts 6 tokens in option 1 (that means that the others put together 4 times 6 = 24 tokens in option 1), it is best for you to put all your 13 tokens in option 1. Please, verify this in the table now. Therefore we remind you that you and the other group members can earn together the maximum possible number of points in any round by putting 6 tokens in option 1 and trusting that the others do the same."

[4] Before participating in the experiment, each subject fulfilled a social valuation task. This task consists of selecting a combination of a number of points the decision maker receives herself, and a number of points to be given to an anonymous other participant. There were 16 combinations to choose from, which

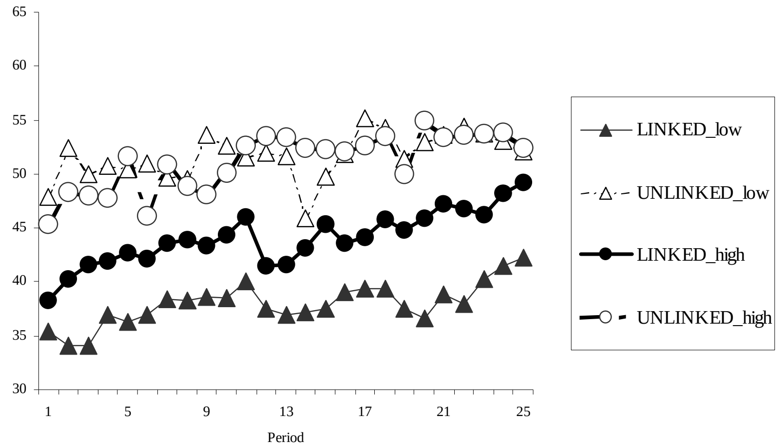


Figure 1: Average group extraction effort in the CPR game.

3 Data analysis

The behavior observed in the experiments is summarized in figures 1 and 2, which allow us to compare aggregate efficiency between the two treatments and to determine the impact of the relative profitability of the gift-giving game on the efficiency of CPR use. Figure 1 presents the average amount of extraction effort in rounds 1 to 25, and figure 2 presents the average number of gifts given in a group in rounds 1 to 25.

We find that the average group extraction effort is above the socially optimal level in both treatments, and is about equal to the Nash equilibrium prediction in the Unlinked

included both positive and negative numbers of points, the latter implying that points can actually be taken away from either the decision maker or from the other participant. Based on the combination chosen, we can label participants as individualistic (maximizing own payoff, giving zero points to the other person), pro-social (giving a positive number of points to the other person, at the expense of the number of points they receive themselves), or spiteful (giving a negative number of points to the other person). We find that the population composition in the Linked and Unlinked treatments does not differ with respect to this measure of other-regarding behavior, and therefore all differences observed in the experiment can be attributed to the treatment variables rather than to subject sampling. The relevant proportions of individualistic, pro-social and spiteful individuals are 28% (29%), 61% (58%) and 11% (14%) in the Linked (Unlinked) treatments. These numbers are similar to the those found in other studies (e.g., Fischbacher et al. [10]).

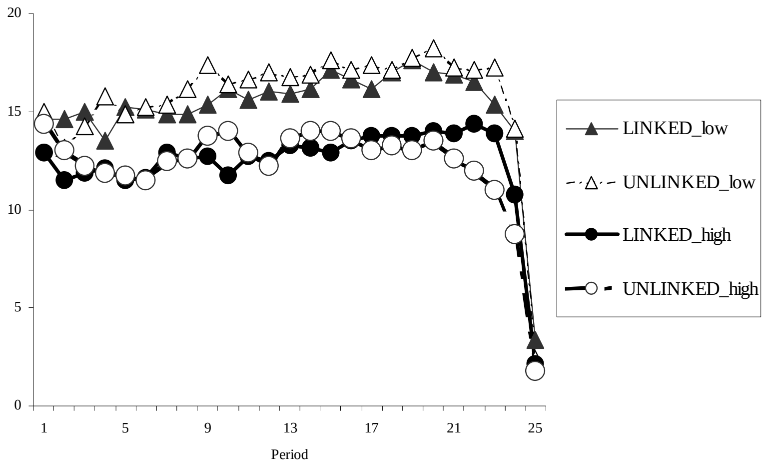


Figure 2: Average number of gifts per group.

Treatment	Low cost	High cost	
Linked	37.98	44.07	p=0.093
Unlinked	51.65	51.19	p=0.270
	p=0.002	p=0.012	

Table 3: Group extraction effort in the CPR game, averaged over all 25 rounds (p-values for a 2-sided Mann-Whitney U-test; 8 observations per cell).

Treatment	Low cost	High cost	
Linked	15.23	12.39	p=0.115
Unlinked	15.77	12.28	p=0.009
	p=0.579	p=0.674	

Table 4: Number of gifts per group, averaged over all 25 rounds (p-values for a 2-sided Mann-Whitney U-test; 8 observations per cell).

treatment (recall that $X^* = 30$ and $X^{NE} = 50$; see table 2). However, in the Linked treatment, average group extraction effort is closer to the socially optimal level, especially in the earlier rounds of the experiment. Hence, we find that CPR use is more efficient in case subjects interact with the same individuals in both games, than if they interact with one group of individuals in the CPR game and with a different group of individuals in the gift-giving game. That the Linked treatment outperforms the Unlinked treatment in terms of efficiency is found to be statistically significant at the 2% level or better; see table 3. This table presents the average extraction effort level over all 25 rounds for the four session types, as well as the p-values for the relevant pairwise Mann-Whitney U-tests. This table also shows that in the Linked treatment, the efficiency improvement in CPR use associated with low costs of giving gifts, is significant, albeit at the 10% level only.

Figure 2 shows that in both treatments and under both cost parameterizations, the number of gifts provided is far above the Nash equilibrium prediction of zero gifts. In the low cost parameterization, the average number of gifts within a group is even fairly close to the socially optimal level ($P^* = 20$; see table 2). Perhaps surprisingly, the number of gifts sent per group does not differ between the two treatments; on average, it is slightly lower in the Linked treatment, but the differences are not significant as can be seen from table 4. This table also shows that the the number of gifts provided is lower the more costly it is, although in the Linked treatment this difference is significant at the 11.5% only.

We summarize these findings in the following three observations:

Observation 1: The average number of gifts in the gift-giving game exceeds the Nash equilibrium level. The level of gift-giving remains high throughout the game except for the last few rounds. Furthermore, the more expensive the gifts are, the fewer are given.

Observation 2: The average group extraction effort in the CPR game is below the Nash equilibrium level in the Linked treatment, and is equal to (or even slightly higher than) the Nash equilibrium level in the Unlinked treatment.

Observation 3: The lower the cost of giving gifts, the lower average extraction effort

	Treatment		
Social task choice	Linked	Unlinked	Total
Other-payoff minimizing	9 (11%)	11 (14%)	20 (13%)
Own-payoff maximizing	22 (28%)	23 (29%)	45 (28%)
Joint-payoff maximizing	49 (61%)	46 (58%)	95 (59%)
Total	80	80	160

Table 5: Numbers of subjects associated with the three behavioral types in the two treatments.

in the CPR game in the Linked treatment. However, the impact appears to be relatively weak as it is significant at the 10% level only.

All three observations are in conflict with the Standard hypothesis, but in line with the alternative hypothesis regarding the potential influence of the presence of reciprocal individuals. At this point we can also note that any differences found across the two treatments do not arise because of biased samples of the subject pool. The social orientation task shows that of the 160 experiment participants, 59% could be labelled socially oriented (joint-payoff maximizing), 28% self oriented (own-payoff maximizing), and 13% spiteful (other's payoff minimizing); see table 5. These numbers are in accordance with earlier analyses of human preferences (e.g., Fischbacher et al. [10]), and the differences in representation across the two treatments are negligible.

Let us now briefly discuss the three observations in turn. Regarding observation 1, our parameterization is such that a reciprocal subject would have to believe that there is *no* other reciprocator in her group in order not to send gifts to all others in the first round of the game.[5] Indeed, the fact that gift exchange starts off at a high level in the first round suggests that there is a substantial number of reciprocal individuals (or strategic money maximizers acting as if they have reciprocal preferences) in each group. To explore the consequences of (as if) reciprocal behavior more formally, let us distinguish two types of reciprocal behavior in the gift-giving game: positive and negative reciprocity. Positive (negative) reciprocity means that subject i does (not) send a gift to subject j ($i \neq j$) in period t if subject j sent (did not send) a gift to subject i in period $t-1$. To test

[5] If a subject sends a gift to all other group members in a round, she pays 8 or 16 points (in the low and high cost parameterization, respectively), while she receives 20 points if only one of the recipients reciprocates (and 40 if all others reciprocate).

Treatment	Positive reciprocity[a]	Negative reciprocity[a]
Linked low	38/40 (95%)	18/40 (45%)
Linked high	36/40 (90%)	27/35[b] (77%)
Unlinked low	38/40 (95%)	28/39[b] (72%)
Unlinked high	32/40 (80%)	28/40 (70%)

[a]Total number of participants per treatment is 40 (8x5).
[b]Not all subjects were exposed to a situation in which they could display negative reciprocity.

Table 6: Fraction of subjects for whom the null of no reciprocity is rejected at the 5 percent level.

for this type of behavior, we analyze each individual subject's gift-giving decision using a binomial test. The null hypothesis is that this individual randomizes between sending and not sending gifts, independent of the recipient's past behavior. The alternative hypothesis is that of positive (negative) reciprocal behavior, as defined above. In table 6 we present the fraction of subjects for whom the null hypothesis is rejected either in favor of positive or negative reciprocity. We find that in all four treatments, a vast majority of individuals are positively reciprocal in the sense that they provide gifts to those fellow group members that sent gifts to them in the previous round. And about 70% of the subjects exhibit significant negatively reciprocal behavior in three of the four treatments.The fact that subjects in the Linked/low cost treatment negatively reciprocate less frequently than subjects in the Linked/high cost treatment may explain observation 3, but we postpone discussing it in detail to section 5, where we analyze individual behavior.

Observation 2 states that efficiency in CPR use is higher in the Linked than in the Unlinked treatment, and we hypothesize that this is due to the fact that in the former treatment, individuals can condition their behavior in the gift-giving game on the observed behavior of their fellow group members in the CPR. This connection is evidenced by the fact that the average individual extraction effort levels in the first round are lower in the Linked than in the Unlinked treatments, and significantly so (irrespective of the costs of gifts); see table 7. That means that it is sufficient just to *inform* the subjects that the two constituent games are played with the same individuals to induce lower extraction effort in the Linked treatment (as compared to the Unlinked treatment).

In addition, we find a strong correlation between the number of gifts received, and a

Treatment	Low cost	High cost	
Linked	7.1	7.7	p=0.255
Unlinked	9.6	9.1	p=0.420
	p=0.024	p=0.000	

Table 7: Average individual CPR extraction effort in round 1 (p-values for a 2-sided Kolmogorov-Smirnov test; 40 observations per cell).

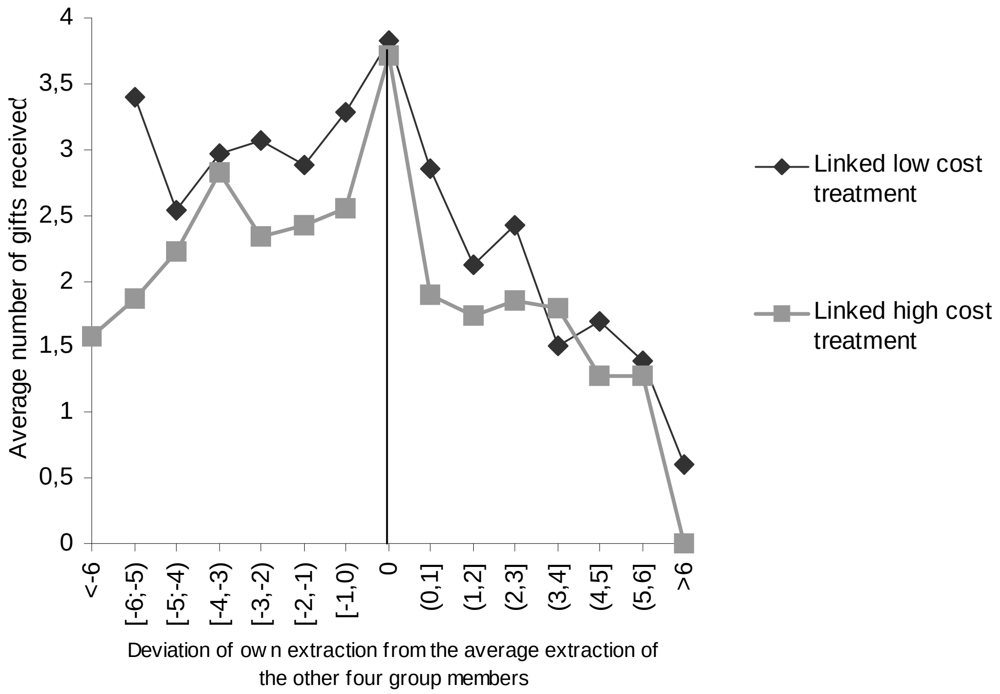


Figure 3: Average number of received gifts as a function CPR extraction in the Linked treatments.

subject's deviation in extraction effort from the group's average[6] (horizontally) and the average number of gifts received (vertically); see Figure 3. We observe that both putting in either more or less effort into CPR extraction than the group's average is correlated with fewer gifts received. This symmetric pattern suggests that free-riders in the CPR game do not give gifts to the very cooperative individuals in the group, as they do not expect to receive gifts from them. However, the relevance of this observation should not be overestimated, First, for extraction levels below the group average the Spearman rank-based correlation coefficient equals -0.663 with a p-value of only 0.086, whereas it is -0.905 with a p-value of 0.002 for the extraction levels above the group average. Second, extracting much less than one's group members does not occur very frequently (the highest level of 'underextraction' contains less than 1% of all observations). Third, these correlation are not conditioned on past behavior, as this can only be tested in a formal regression analysis as presented in the next section. However, the following observation does hold:

Observation 4: In the Linked treatment, the number of gifts received in the gift-giving game is correlated with the gift recipient's extraction effort in the CPR game.

Hence, the group data suggest that embedding a social dilemma situation in a wider economic context (by adding the gift-giving game) gives rise to more cooperation in the social dilemma situation than predicted by economic theory. Moreover, whereas the pecuniary punishment mechanism results in only a marginal increase in net efficiency (because of the 'deadweight loss' associated with the costs of imposing sanctions; see Ostrom et al. [15]), the selective exclusion mechanism uncovered here results in a pure efficiency gain: whereas aggregate extraction effort in the CPR game is closer to social optimum level in the Linked treatment than in the Unlinked treatment, the total number of gifts provided is identical (as it depends on the costs of gift-giving only).

[6] In terms of the model, $x_{i,t} - \frac{1}{N-1}\sum_{j\neq i} x_{j,t}$.

4 Analysis of individual behavior

Having observed that linking the CPR game and the gift-giving game results in improved efficiency of the CPR game without decreasing efficiency in the gift-giving game, we now turn to analyzing individual behavior to explain the mechanism behind this observation. Here, three questions are pertinent. First, what factors explain the number of gifts received? Is it determined by the number of gifts an individual sent to others in the previous period, or does it also depend on the individual's extraction behavior in the CPR game in the current period? Second, what factors explain extraction effort by individual subjects? Is it just the aggregate extraction effort by the other subjects in the group, or does it also depend on the number of gifts received? In other words, does a decrease in the number of gifts received in the previous period induce the individual to reduce extraction effort in the current period, or not? And third, how does an individual who is being sanctioned in the gift-giving game for excessive extraction in the CPR game respond when deciding whom to give gifts to? Does this individual accept the decrease in the number of gifts as a fair punishment for his/her extraction behavior, or does he/she decide to retaliate by not sending gifts to the person imposing the sanction? Answers to these questions will give insight into why linking the two games results in improved efficiency in the CPR game.

Let us first analyze the determinants of the number of gifts received by each subject, and let us denote this variable with $GR_{i,t}\left(=\sum_{j\neq i} p_{ji,t}\right)$. Straightforward reciprocity by the other subjects implies that in both treatments, the number of gifts received is positively related to the number of gifts a subject gave in the previous period $\left(GG_{i,t-1}\left(=\sum_{j\neq i} p_{ij,t-1}\right)\right)$. In the Linked treatment, however, sanctioning may take place, and hence we also include a subject's extraction effort exerted in the same round. We explore two specifications, referred to as L1 and L2. L1 includes a dummy variable whether individual i's extraction effort exceeded the social optimal extraction level ($nv_{i,t} = 1$ if $x_{i,t} > 6$; zero otherwise), as well as a variable reflecting the extent of the norm violation ($exnv_{i,t} = (x_{i,t} - 6) * nv_{i,t}$). L2 includes a simple measure of relative overextraction, which is constructed as follows: $rx_{i,t} = x_{i,t} - \frac{1}{N-1}\sum_{j\neq i} x_{j,t}$.

The regression results are presented in table 8. As the dependent variable is an integer number between 0 and 4, we use a count model (quasi maximum likelihood); Huber/White standardized errors are presented in parenthesis. We find strong evidence for direct reciprocity within the gift-giving game, as the coefficient on $GG_{i,t-1}$ is positive and significant in all regressions. Consistent with our alternative hypothesis, we find that the lower the cost of gifts, the higher the number of gifts received as evidenced by the significancy of the coefficients of the variables that are interacted with DL (a dummy variable indicating the low (high) cost parameterization; $DL = 1(0)$). Furthermore, both specifications L1 and L2 show that the number of gifts received depends negatively on own extraction effort. The fact that in L1 the absolute norm ($nv_{i,t}$) is not found to be significant whereas the extent of the norm violation ($exnv_{i,t}$) is, suggests that more excessive extraction is punished harder, and hence that the sanctioning device is not able to implement the social optimum. L2 shows that the relative measure performs about equally well, as evidenced by the log likelihoods of specifications L1 and L2.

Now let us turn to the analysis of changes in extraction effort. In both treatments, it is expected to depend on the extraction effort of others, either the change in aggregate extraction, or the one's relative extraction effort (as compared to the group's average, $rx_{i,t}$). But in the Linked treatment subjects may also adjust their extraction effort in response to changes in the number of gifts received, although one would not expect the relationship between these two variables to be symmetric. A decrease in the number of gifts received can be interpreted as punishment and hence may induce a reduction in extraction effort, but one would not expect the amount of effort to increase again if the number of gifts received goes up. Therefore, we use as explanatory variables both the change in gifts received ($\Delta GR_{i,t-1}$) as well as the absolute change in gifts received ($|\Delta GR_{i,t-1}|$).[7]

In table 9 we present the regression results explaining the change in extraction effort ($\Delta x_{i,t} = x_{i,t} - x_{i,t-1}$); the analysis is by means of ordinary least squares. The relative extraction effort measure ($rx_{i,t}$) outperforms the variable reflecting the change in aggre-

[7] Thus, we focus on analyzing *changes* in the amount of effort allocated to resource harvesting rather than on *levels* of extraction effort. High levels of cooperation in the gift-giving game may be associated with high levels of cooperation in the CPR game, but cooperation in the former game may also be high if subjects do not wish to jeopardize profitable bilateral cooperation to obtain small gains in their private return to resource harvesting in the CPR game.

	(U1)	(L1)	(L2)
Constant	0.157***	0.362***	0.123***
	(0.041)	(0.042)	(0.040)
$GG_{i,t-1}$	0.290***	0.248***	0.282***
	(0.013)	(0.012)	(0.012)
$GG_{i,t-1} * DL$	0.013***	0.026***	0.037***
	(0.004)	(0.005)	(0.005)
$nv_{i,t}$		0.008	
		(0.041)	
$nv_{i,t} * DL$		-0.007	
		(0.056)	
$exnv_{i,t}$		-0.057***	
		(0.010)	
$exnv_{i,t} * DL$		-0.003	
		(0.016)	
$rx_{i,t}$			-0.061***
			(0.009)
$rx_{i,t} * DL$			-0.030**
			(0.015)
Log likelihood	-3335.44	-3277.52	-3277.85
Number of observations	1520	1520	1520

*Significant at 10% level, **Significant at 5% level,
***Significant at 1% level.

Table 8: Factors determining the number of gifts received in rounds 1 to 20 (Huber/White stadard errors presented in parenthesis)

gate extraction effort, and therefore we only present the former specifications. In both treatments, we find that individuals tend to adjust their extraction efforts towards the group's mean; if one's effort is above (below) the mean, one adjusts one's effort downward (upward). When not distinguishing between the high and low cost parameterizations (L1), we find a symmetric effect with respect to the number of gifts received. However, the symmetry is lost when we distinguish between the two parameterizations, as can be viewed from regressions L1h and L1l. These present the regression results using just the observations from the high- and low cost treatments, respectively. We find that in the high-cost parameterization, the relationship is symmetric (as $|\Delta GR_{i,t-1}|$ fails to be significant), but not so in the low-cost parameterization. If the number of gifts received in the previous period decreases ($\Delta GR_{i,t-1} < 0$), the relevant coefficient is -0.203 ($= 0.5 * (-0.249 - 0.157)$), and this coefficient is significant at the 1% level.[8] If the number of gifts received in the previous period increases ($\Delta GR_{i,t-1} > 0$), the relevant coefficient is insignificant and equal to 0.046 ($= 0.5 * (0.249 - 0.157)$). Therefore, in the Linked/low cost treatment, a decrease in the number of gifts received induces the decision maker to reduce extraction effort, whereas an increase does not result in a change in the amount of effort allocated to resource harvesting.

Finally, let us address the question whether sanctioning potentially jeopardizes cooperation in the gift-giving game, or not. If subjects increase their extraction levels and subsequently receive fewer gifts in that period, do they view that reduction as a deserved punishment for their excessive extraction behavior? Or do they retaliate by reducing the number of gifts they provide to the others? We analyze this question by means of an ordered probit model with three possibilities: the subject decreases the number of gifts provided in the current period, keeps it unchanged or increases it ($\bar{G}\bar{G}_{i,t} = 1, 0$, or -1 if $\Delta GG_{i,t}$ is positive, zero or negative). We test for the response to being punished by including the change in total number of gifts received (by the subject) in the previous period, $\Delta GR_{i,t-1}$. If punishment of the CPR behavior in the gift giving game does cause

[8] Significancy is determined by regressing the dependent variable in L1l on $(\Delta GR_{i,t-1} + |\Delta GR_{i,t-1}|)$ and $(\Delta GR_{i,t-1} - |\Delta GR_{i,t-1}|)$, as well as on $rx_{i,t}$. The first (second) variable is positive (zero) if the number of gifts received increases, and the first (second) variable is zero (negative) in case the the number of gifts received dencreases.

	(U1)	(L1)	(L1h)	(L1l)
Constant	0.040	0.060	-0.012	0.105
	(0.065)	(0.063)	(0.099)	(0.080)
$rx_{i,t-1}$	-0.647***	-0.470***	-0.450***	-0.489***
	(0.029)	(0.026)	(0.056)	(0.038)
$\Delta GR_{i,t-1}$		0.225***	0.190**	0.249***
		(0.057)	(0.091)	(0.072)
$\lvert\Delta GR_{i,t-1}\rvert$		-0.037	0.135	-0.157*
		(0.071)	(0.118)	(0.087)
$adj\ R^2$	0.252	0.209	0.198	0.230
Number of observations	1440	1440	720	720
*Significant at the 10% level, **Significant at 5%, ***Significant at 1%.				

Table 9: Factors determining the change in the amount of effort allocated to resource harvesting in rounds 1-20 (Huber/White standard errors presented in parenthesis).

cooperation in the gift-giving game to unravel, we expect that this variable is positively and significantly correlated with the dependent variable, *unless* the subject under consideration increased his/her extraction in period $t-1$ and views the reduction in number of gifts received as a deserved punishment. We capture whether the sanction can be considered deserved by constructing an indicator function $Des_{i,t}$, with $Des_{i,t} = 1(0)$ if $\Delta x_{i,t} > 0$ (≤ 0). The gift-exchange does not unravel if the coefficient on $Des_{i,t-2} * \Delta GR_{i,t-1}$ turns out not to be significant, and if the coefficient on $(1 - Des_{i,t-2}) * \Delta GR_{i,t-1}$ is positive and significant. If the coefficient on $Des_{i,t-2} * \Delta GR_{i,t-1}$ turns out to be positive and significant, though, sanctioning is a hazardous activity as refusing to give gifts to individual i (resulting in $\Delta GR_{i,t-1} < 0$) induces subject i to decrease the number of gifts she provides to others. Obviously, direct reciprocity with respect to gift-giving and responses with respect to possible sanctions are not the only drivers determining the number of gifts provided by individual i; she may also decide to punish norm violators herself. Therefore, we also include changes in extraction behavior by the other subjects (as measured by $\Delta X_{-i,t}$) as an explanatory variable. The results of the regression analysis are presented in table 10.

In both the high- and low-cost parameterization regressions (L1h and L1l, respectively), we find that the number of gifts provided is likely to increase the more others reduce their aggregate extraction effort; subjects reward that by sending more gifts. Also,

	(L1h)	(L1l)
$\Delta GR_{i,t-1}*(1-Des_{i,t-2})$	0.199***	0.245***
	(0.068)	(0.070)
$\Delta GR_{i,t-1}*Des_{i,t-2}$	0.461***	0.161*
	(0.145)	(0.093)
$\Delta X_{-i,t}$	-0.048***	-0.073***
	(0.013)	(0.013)
Log likelihood	-608.55	-629.30
Number of observations	720	720
*Significant at the 10% level, **Significant at 5%, ***Significant at 1%.		

Table 10: Factors determining the number of gifts provided in the Linked/high and Linked/low cost treatments.

consistent with expectations, the positive coefficient on $\Delta GR_{i,t-1} * (1 - Des_{i,t-2})$ reflects that subject i decides to increase (decrease) the number of gifts she provides if she received more (fewer) gifts in the previous period, irrespective of the costs of gift-giving. But the fact that the coefficient on $\Delta GR_{i,t-1} * Des_{i,t-2}$ is also positive and significant in L1h but much smaller and is hardly significant (at the 8.4% level only) in L1l, is revealing. L1h shows that if subject i receives fewer gifts in the previous period because she increased his/her extraction effort in that period, she does reduce the number of gifts she provides in the current period. Therefore, if she is sanctioned, she responds by sending fewer gifts, and the gift-giving relationship unravels. This effect is, however, much smaller in the low-cost parameterization. Hence, sanctioning is indeed a hazardous enterprise, but especially so in the high-cost treatment where refusing to give gifts constitutes a relatively large cost saving. Note that this is in line with data presented in table 6, where we find that negative reciprocity in the gift giving game in the Linked treatment is more likely when the cost of gift giving are high than when they are low.

5 Conclusions

A substantial amount of experimental research has been undertaken to explain under what circumstances cooperation in social dilemmas can be sustained without centralized intervention. The self-regulatory institution that has been analyzed most extensively is that of decentralized pecuniary punishment, where subjects can impose costly punishment on free-riders. In this paper we explore the effectiveness of a more natural self-regulatory mechanism, based on the observation that agents tied in a social dilemma game are often also dependent on (bilateral) cooperation in other economic activities. Selectively excluding individuals who free-ride in the social dilemma situation from the benefits of cooperation in these alternative economic activities may be used as a sanctioning device. We model the social dilemma game as a standard CPR game and the alternative type of economic activity as a two-sided gift-giving game.

Our experiments show that indeed selective exclusion occurs naturally if subjects interact with the same group of individuals in both activities, and is an effective mechanism in enforcing cooperation in the CPR game. In the community treatment (the Linked treatment), efficiency in CPR management is significantly higher than in the Unlinked treatment, where subjects are not able to selectively exclude CPR free-riders from the benefits of the gift-giving game, whereas the efficiency of the gift-giving game is identical across the two treatments. That means that, unlike the pecuniary punishment mechanism, aggregate efficiency unambiguously increases when linking the two games. In addition, the more profitable the gift exchange as compared to the CPR game, the more effective the mechanism is. However, the exclusion mechanism is not able to fully implement the social optimum in the CPR game, as we find no evidence that the number of gifts received drops to zero whenever a subject puts in more extraction effort than is socially optimal. Rather, the more a subject's extraction effort exceeds that of the group's average, the fewer gifts he/she receives.

Thus, our experiments suggest that strengthening community ties gives rise to powerful pro-social incentives with respect to cooperation in social dilemma situations and hence improves community welfare.

6 Appendix 1 - Instructions for participants

In this appendix, we present the instructions to participants in both treatments. When not noted otherwise, a paragraph of the instructions was read in both treatments, Linked and Unlinked. In some paragraphs, we insert into square brackets sentences that were read only in one of the treatments, and indicate at the start of the bracket for which treatment this holds. Otherwise, the paragraphs were read in the order as presented in this appendix.

Introduction (Linked treatment): In the experiment, you will be in a group with four other participants; a group therefore consists of five participants in total. You will not learn the identity of the other members of your group. The experiment lasts 25 rounds. Every round consists of two parts, Part I and Part II. In each part, you will make one decision. You will earn points for your decisions in Part I and Part II. At the end of the experiment, you will be paid real money for all the points you earned in Part I and Part II over all 25 rounds. The exchange rate is: 100 points = 1 Euro, 1 point = 1 Euro-cent. We will now describe Part I and Part II of one round.

Introduction (Unlinked treatment): The experiment that you now participate in, will last 25 rounds. Every round consists of two parts, Part I and Part II. In every part, you will be matched to four participants in this room. A group therefore consists of five participants in total. However, the two groups, the group in Part I and the group in Part II, do NOT consist of the SAME participants. You will be matched to four participants in Part I, and to four DIFFERENT participants in Part II. You will not learn the identity of the other members of any of the two groups. To emphasize that the other participants in the two parts are not the same people, the four participants you are in a group with in Part I, are labeled z, zz, zzz, zzzz. The four (other) participants you are in a group with in Part II are labeled A, AA, AAA, AAAA. In each of the two parts in every round, you will make one decision. You will earn points for your decisions in Part I and Part II. At the end of the experiment, you will be paid real money for all the points you earned in Part I and Part II over all 25 rounds. The exchange rate is: 100 points = 1 Euro, 1 point = 1 Euro-cent. We will now describe Part I and Part II of one round.

Part I of one round: [Only Unlinked: In Part I of any round you are in a group with 4 group members called z, zz, zzz, zzzz.] At the beginning of every Part I of a round, you receive 13 tokens. You have to decide how to divide these 13 tokens between two options: option 1 and option 2. Observe that you have to divide all your 13 tokens. Therefore if you put X tokens into option 1, you put automatically 13 - X tokens into option 2. In the experiment, therefore, you will be asked to make one choice: how many tokens you put in option 1. It is then automatic that you put 13 - X tokens in option 2.

Earning points in Part I: Now, we will explain how you earn points for the tokens you put in option 1 and option 2.

Earnings for tokens in option 1: The number of points you earn for the tokens in option

1 depends on how many tokens you put in option 1 and how many tokens the other four group members [Only Unlinked: z, zz, zzz, and zzzz] put in option 1. put in option 1. You receive 9.5 points for every token you put in option 1. You also have to pay costs when using option 1. The costs depend on how many tokens in total all group members (including you) put into option 1: for every token you put into option 1, you have to pay a cost of 0.15 points MULTIPLIED BY the total number of tokens in option 1.

Earnings for tokens in option 2: The number of points you earn for the tokens in option 2 depends only on how many tokens you put in option 2. For every token in option 2 you receive 0.5 points. There are no costs. Your total earnings in Part I are the sum of points you earn in option 1 and 2, that means 9.5*X - 0.15*(X+Y)*X +0.5*(13 - X), where X is the number of tokens you put into option 1, and Y is the total number of tokens that are put into option 1 by the other four group members.

Earnings table of Part I: Rather than using the formula presented above, you can refer to the table in front of you when making your decisions in Part I. The Table presents the number of points you can earn in Part I of a round for different combinations of the number of tokens you put in option 1 and the total number of tokens the other four group members put in option 1. Please, have a look at the Table now. [Payoff table distributed to the experiment participants.]

In the first column (in grey print), you find all possible numbers of tokens you may put in option 1. You can choose any integer number from 0 to 13, that means numbers 0,1,..,12,13. In the first row (in grey print), you find the number of tokens the other four participants may (together) put in option 1. Your total payoff in Part I depends on the combination of the number of tokens you put in option 1 and the number of tokens the other four participants (in total) put in option 1.

Example. Suppose you put 4 tokens in option 1. In the grey column, find the row that begins with 4 (tokens). And, suppose you think that the other four group members will put in total 12 tokens in option 1. In the grey row, find the column that begins with 12 (tokens). Look in the table for the intersection of the chosen row (4 tokens) and column (12 tokens). You find that if you put 4 tokens in option 1 and the other four members put in total 12 tokens in option 1, your total earnings in Part I of the round are 32.9 points.

In the table, observe the following. You can always make sure to earn 6.5 points in any round by putting zero tokens in option 1. You can, however, possibly earn more points if you put some tokens in option 1. How many points you earn, depends crucially on the choices of the other members of your group. If, for example, you put all 13 tokens in option 1, you can earn 98.2 points, if the other group members do not put any tokens in option 1. On the other hand, you can lose 3.3 points, if the other group members do the same as you do, and put all their tokens in option 1. Other group members affect how many points you earn, and you affect how many points the others earn.

We would like to draw your attention to the fact that as a group, you and the other group members can earn the maximum number of points together if each group member puts 6 tokens in option 1. Note, however, that if every other group member puts 6 tokens in option 1 (that means that the others put together 4 times 6 = 24 tokens in option 1), it is best for you to put all your 13 tokens in option 1. Please, verify this in the table now. Therefore we remind you that you and the other group members can earn together the maximum possible number of points in any round by putting 6 tokens in option 1 and trusting that the others do the same.

Note that in the experiment, you and the other four members of your group will decide on the division of the tokens at the same time. Therefore, at the moment of your decision you do not know how many tokens the other members of your group will put in option 1. You can only guess. After all group members made their decisions in Part I, you will receive information about how many tokens each group member has put in option 1 in this round, and how many points each group member earned.

Part II of one round: [Only Unlinked: In Part II of any round you are in a group with 4 group members called A, AA, AAA, AAAA. These are not the same individuals as those labeled z,zz,zzz,zzzz in Part I.] In Part II of a round (following immediately Part I), you will make a choice on how to use some of the points you earned in Part I. In particular, for each of the other four group members [Only Unlinked: A, AA, AAA, and AAAA], you have to decide whether or not to send 2 points to that group member. If you happen not to have earned enough points in Part I, you can still send 2 points to any of the other group members, and these points will be subtracted from your total earnings.

Earning points in Part II: Any points you send to any of the other group members will be subtracted from the number of points you earned.

When you send points to the other group members, they receive more points than you sent. How many more depends on how many other group members also sent them 2 points. See the following table: If no person sends 2 points to a specific group member, that member receives 0 points; If 1 person sends 2 points to a specific group member, that member receives 20 points; if 2 persons send 2 points to a specific group member, that member receives 30 points; if 3 persons send 2 points to a specific group member, that member receives 36 points; if 4 persons send 2 points to a specific group member, that member receives 40 points.

Observe that all individuals in your group make this decision at the same time as you. That means, similarly, that if no person sends 2 points to you, you receive 0 points; if 1 person sends 2 points to you, you receive 20 points; if 2 persons send 2 points to you, you receive 30 points; if 3 persons send 2 points to you, you receive 36 points; if 4 persons send 2 points to you, you receive 40 points.

At the end of Part II of a round you will be informed about how many points each other group member has sent to you, and the total number of points collected by each other individual [Only Unlinked: A, AA, AAA, and AAAA] in this round. Then, a new round will begin. Your total earnings in one round of the experiment are: the number of points you earned in Part I, MINUS the number of points you send to others in Part II, PLUS the number of points you received from others in Part II, depending on how many of them sent points to you.

We will now explain how the computer screens look like.

Computer screens: As a general rule: the text in a line where you make a decision is always shown in RED; all information about Part I of a round is shown in GREEN, all information about Part II of a round is shown in BLUE.

Screen 1: Here you decide how many tokens you put in option 1. Use the keyboard to type in one of the numbers 0, 1,...,12, 13 in the active field, and confirm your choice by pressing OK. Warning: Before pressing OK, make sure your choice is correct. You cannot change your decision after you have pressed OK.

After having pressed OK, you will be asked to wait until all experiment participants have done the same. The experiment continues only after all experiment participants pressed OK. We therefore kindly ask you not to delay your decision too much. For every decision, a time indication of one minute is shown in the header. After this time expires, you are repeatedly asked to submit your decision, or press the OK button.

For your information, there are two history tables in the lower part of Screen 1. The history table of Part I contains information for all previous rounds on how many tokens each group member [Only Unlinked: (labeled z,zz,zzz,zzzz)] has put in option 1 in that round. The history table of Part II contains information for all previous rounds on whether a group member [Only Unlinked: (labeled A,AA,AAA,AAAA)] sent 2 points to you in that round, or not. At the beginning of round 1, these fields will of course be empty.

In the history tables, the information about yourself is always shown in the second column of the table, denoted “me”. In columns three to six, you find information about the other four group members. [Only Linked: These columns are denoted x, xx, xxx, and xxxx only. Note that these “names” remain the same for each group member over the whole experiment. For example in the column denoted “xx”, you will always find information about one and the same group member, but you will not learn his/her identity.] [Only Unlinked: These columns are denoted z, zz, zzz, and zzzz (or A,AA,AAA,AAAA) only. Note that these “names” remain the same for each group member over the whole experiment. For example in the column denoted “zz”, you will always find information about one and the same group member, but you will not learn his/her identity. After pressing OK, a waiting screen will appear. After all experiment participants have pressed OK, Screen 2 will appear.

Screen 2: In the left part of this screen you find a table with information on how many tokens each group member [Only Linked: x, xx, xxx, xxxx] [Only Unlinked: labeled z, zz, zzz, and zzzz,] has put in option 1 in this round, and how many points he/she earned in Part I.

In the right part of the screen, you have to decide for each of the other four group members [Only Unlinked: labeled A,AA,AAA,AAAA] whether you want to send 2 points to that group member or not. For each group member, you have to click in the line starting with the text “I send 2 points to this group member” either the field “no” or the field “yes”. In the first case, that group member does NOT receive any points from you. In the second case, 2 points are subtracted from your earnings, and the other group member receives points depending on how many group members sent points to him/her. Press OK, when you are ready to continue. A waiting screen will appear. The experiment continues only after all experiment participants have pressed OK, and therefore we kindly ask you not to delay your decision too much.

Screen 3: In this screen you find all information about this round. In the left part of the screen you find a table with information on how many tokens each group member has put in option 1 in this round and how many points he/she earned in Part I.

In the right part of the screen you find a table with information on each of the group members. In line two of the table, it is shown whether you sent 2 points to that group member (yes/no), and in line three of that table you find whether that group member did sent 2 points to you (yes/no).

Conclusion: Please, raise your hand if you have questions at this moment. Note that we do not answer questions of the type “what shall I do in the experiment?” - it is your own decision. We are,

POINTS EARNED IN MARKET I AND MARKET II

Tokens put in Market I by me	Total number of tokens put in Market I by the other FOUR group members													
	0	**4**	**8**	**12**	**16**	**20**	**24**	**28**	**32**	**36**	**40**	**44**	**48**	**52**
0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
1	15.4	14.8	14.2	13.6	13	12.4	11.8	11.2	10.6	10	9.4	8.8	8.2	7.6
2	23.9	22.7	21.5	20.3	19.1	17.9	16.7	15.5	14.3	13.1	11.9	10.7	9.5	8.3
3	32.2	30.4	28.6	26.8	25	23.2	21.4	19.6	17.8	16	14.2	12.4	10.6	8.8
4	40.1	37.7	35.3	32.9	30.5	28.1	25.7	23.3	20.9	18.5	16.1	13.7	11.3	8.9
5	47.8	44.8	41.8	38.8	35.8	32.8	29.8	26.8	23.8	20.8	17.8	14.8	11.8	8.8
6	55.1	51.5	47.9	44.3	40.7	37.1	33.5	29.9	26.3	22.7	19.1	15.5	11.9	8.3
7	62.2	58	53.8	49.6	45.4	41.2	37	32.8	28.6	24.4	20.2	16	11.8	7.6
8	68.9	64.1	59.3	54.5	49.7	44.9	40.1	35.3	30.5	25.7	20.9	16.1	11.3	6.5
9	75.4	70	64.6	59.2	53.8	48.4	43	37.6	32.2	26.8	21.4	16	10.6	5.2
10	81.5	75.5	69.5	63.5	57.5	51.5	45.5	39.5	33.5	27.5	21.5	15.5	9.5	3.5
11	87.4	80.8	74.2	67.6	61	54.4	47.8	41.2	34.6	28	21.4	14.8	8.2	1.5
12	92.9	85.7	78.5	71.3	64.1	56.9	49.7	42.5	35.3	28.1	20.9	13.7	6.5	-0.7
13	98.2	90.4	82.6	74.8	67	59.2	51.4	43.6	35.8	28	20.2	12.4	4.6	-3.3

Figure 4: Payoff table for the CPR game.

however, happy to answer any questions about the way your points are calculated, or how the computer program works. The experiment now starts with a short test to make sure that everybody understands how points are earned. Use your tables to answer the following questions. After all experiment participants answered all questions correctly, the experiment will begin by 5 trial rounds. You will not be paid for any decisions made in these trial rounds. We encourage you to use these rounds to learn to use of the program. After the 5 trial rounds we will announce the start of the real experiment, and you will play 25 rounds for which you will be paid at the end of the experiment.

Next, we present the computer screens from the Unlinked treatment in figures 5-7. Note that the Linked treatment screens had the same appearance, up to the point that the History Tables in left and right part of the screen referred to the individuals labelled by the same names x, xx, xxx, xxxx, to stress the fact that the decisions in both parts of the game were taken in the same group of participants.

7 Appendix 2 - Social orientation task

Subjects were presented with the table 8.

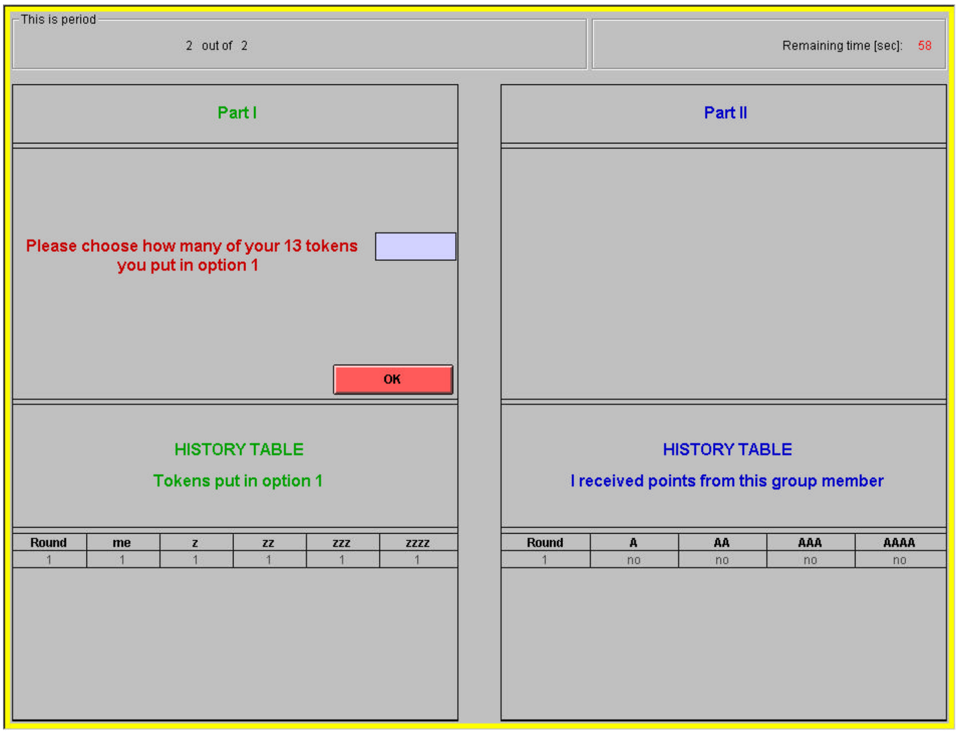


Figure 5: Screen 1 (Unlinked treatment)

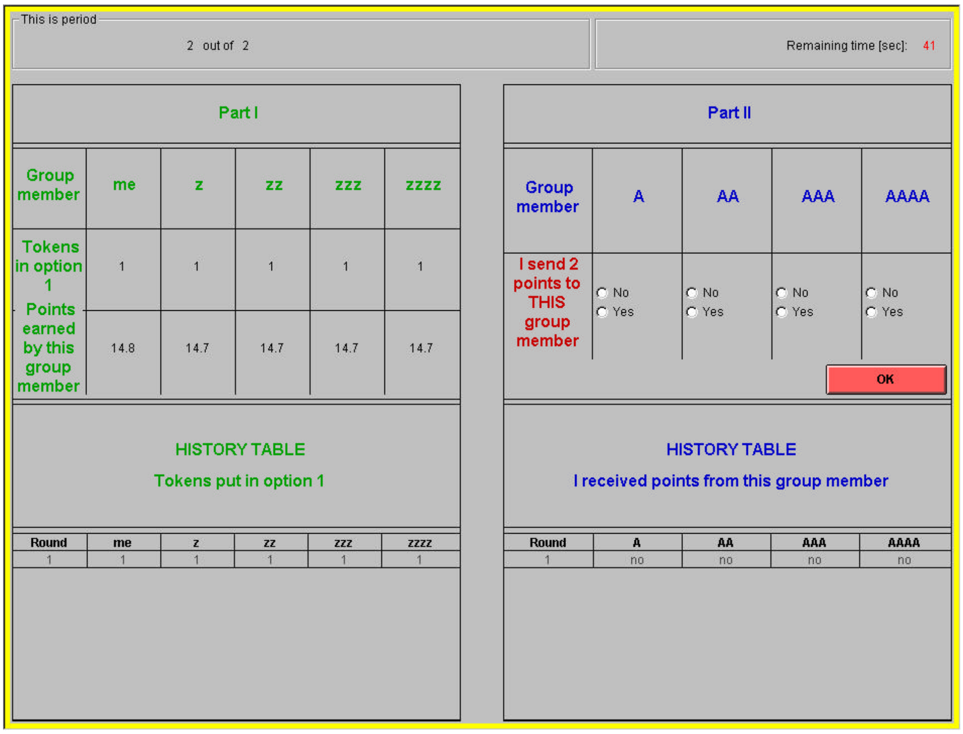


Figure 6: Screen 2 (Unlinked treatment)

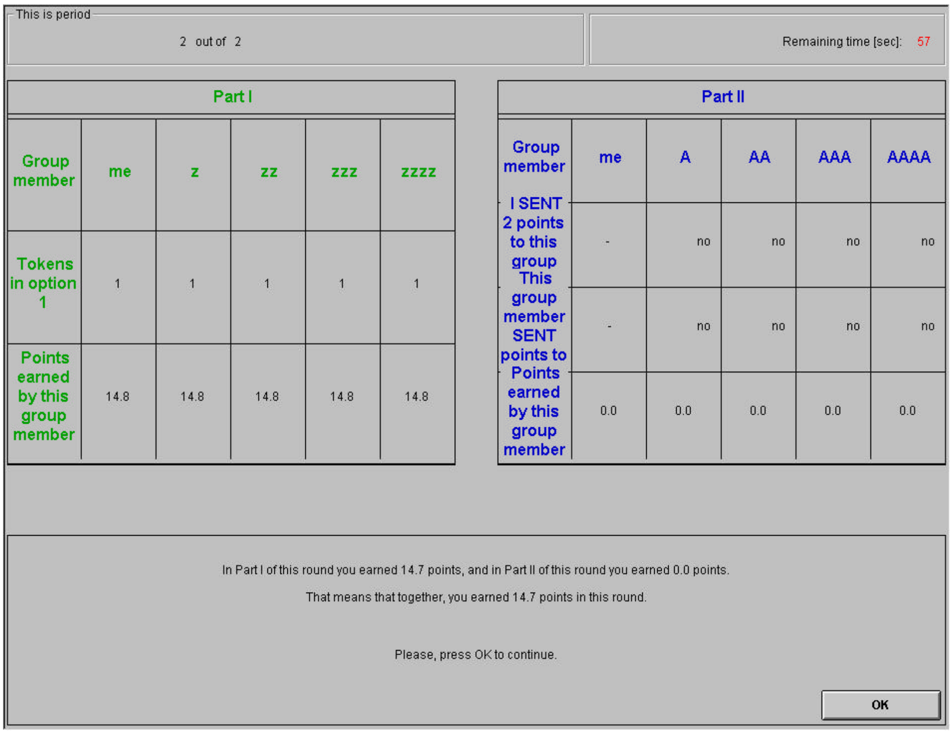
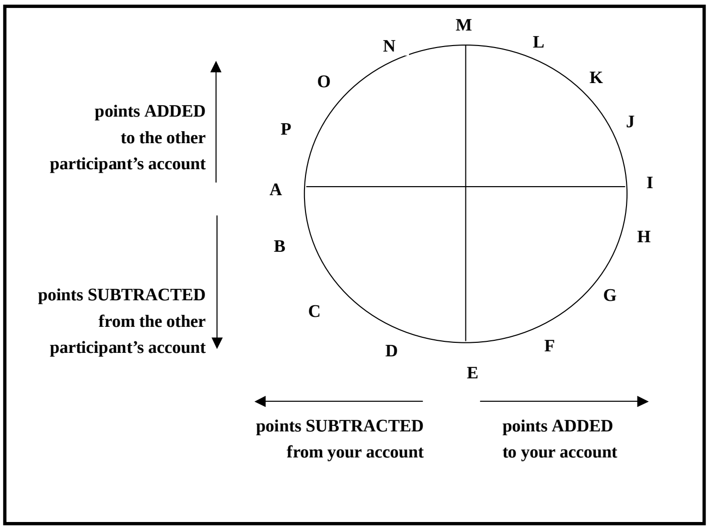


Figure 7: Screen 3 (Unlinked treatment)

Please, choose one of the locations A,B,...,O,P. You and one anonymous other person in this room will be paid according to your choice after the experiment.



Location	Points to YOU	Points to the OTHER PARTICIPANT
A	-211	0
B	-188	-95
C	-150	-150
D	-95	-188
E	0	-211
F	95	-188
G	150	-150
H	188	-95
I	211	0
J	188	95
K	150	150
L	95	188
M	0	211
N	-95	188
O	-150	150
P	-188	95

Figure 8: The social orientation task.

8 Appendix 3 - Post-experimental questionnaire

The following questionnaire was presented to all subjects after the experiment.

Linked treatment:

Question 1: Information on what the others did in Part I of a round was useful when taking decisions in Part II of that round: (i) not useful; (ii) I do not know; (iii)useful.

Question 2: In the experiment, I would prefer the other group members NOT to get information on what I did in Part I, when they are taking their decisions in Part II: (i) I do not mind if they get information on what I did in Part I;(ii) I WANT them to receive information on what I did in Part I;(iii) I prefer if they do NOT receive information on what I did in Part I.

Question 3: In the experiment, I would prefer to be in one group for Part I and in a DIFFERENT group for Part II. Of course, this would imply that when in Part II, I do not know what the other group members did in Part I, and vice versa: (i) I do not mind if I am in the same group in Part I and Part II; (ii) I WANT to be in the same group in Part I and Part II; (iii) I prefer NOT to be in the same group in Part I and Part II.

Unlinked treatment:

Question 1: When taking decisions in Part II of a round, it would be useful to know what the other group members did in their Part I: (i) not useful; (ii) I do not know; (iii) useful.

Question 2: In the experiment, I would prefer the other group members NOT to know what I did in Part I, when they are taking their decisions in Part II: (i) I do not mind if they see what I did in Part I; (ii) I WANT them to see what I did in Part I; (iii) I prefer if they do NOT see what I did in Part I.

Question 3: If I could, I would choose to be in the same group for Part I and Part II: (i) no; (ii) yes.

The answers to the questionnaire are summarized in the table 11. Briefly, we find that in the Linked treatment, most subjects acknowledge the desirability of the selective exclusion mechanism. 79% of them state that linking the two games was useful, 54% prefer that others are informed about their behavior in the CPR game when talking the gift-giving decisions, and 66% prefer linking of the two games compared to unlinked environment. Experience with the Linked treatment is important as among the subjects who participated in the Unlinked treatment, the respective percentages are only 38%, 25% and 48%.

		Answer			Total
Treatment	Question	(i)	(ii)	(iii)	
Linked	1	16/80 (20%)	1/80 (1%)	63/80 (79%)	80
Linked	2	17/80 (21%)	43/80 (54%)	20/80 (25%)	80
Linked	3	20/80 (25%)	53/80 (66%)	7/80 (9%)	80
Unlinked	1	47/80 (59%)	3/80 (4%)	30/80 (38%)	80
Unlinked	2	33/80 (41%)	20/80 (25%)	27/80 (34%)	80
Unlinked	3	42/80 (53%)	38/80 (48%)	NA	80

Table 11: Answers to the questionnaire.

References

[1] Andreoni, J. and Miller, J.H. (1993), "Rational Cooperation in the Finitely Repeated Prisoner's Dilemma: Experimental Evidence", Economic Journal 103, 570-585.

[2] Baland, J. and Platteau, J.P. (1996), Halting Degradation of Natural Resources: Is there a Role for Rural Communities?, Oxford: Clarendon Press.

[3] Berg, J., Dickhaut, J. and McCabe, K. (1995): "Trust, Reciprocity and Social History", Games and Economic Behavior 10, 122-142.

[4] Bowles, S. and Gintis, H. (2002), "Social Capital and Community Governance", Economic Journal 112, 416-436.

[5] Cordell, J.C. and McKean, M.A. (1992) "Sea tenure in Bahia, Brazil", in D.W. Bromley and D. Feeny (eds.), Making the Commons work, San Francisco: ICS Press, 183-205.

[6] Falk A., Fehr E. and Fischbacher U. (2000), "Appropriating the Commons - A Theoretical Explanation", IEW Working Paper 55, Zurich: University of Zurich.

[7] Fehr, E. and Gächter, S. (2000), "Fairness and Retaliation: The Economics of Reciprocity", Journal of Economic Perspectives 14, 159-181.

[8] Fehr, E. and Gächter, S. (2000), "Cooperation and Punishment in Public Goods Experiments", American Economic Review 90, 980-994.

[9] Fischbacher, U. (1999), "z-Tree. Toolbox for Readymade Economic Experiments", IEW Working paper 21, University of Zurich.

[10] Fischbacher, U., S. Gächter and E. Fehr (2001), "Are People Conditionally Cooperative? Evidence from a Public Goods Experiment", Economics Letters 71(3), 397-404.

[11] Granovetter, M. (1985) "Economic Action and Social Structure: The Problem of Embeddedness", American Journal of Sociology 91, 481-510.

[12] Hviding, E. and Baines, G.B.K. (1994) "Community-Based Fisheries Management, Tradition and Challenges of Development in Marovo, Solomon Islands", Development and Change 25, 13-39.

[13] McCarthy, N., Sadoulet, E. and De Janvry, A. (2001), "Common Pool Resource Appropriation under Costly Cooperation", Journal of Environmental Economics and Management 42, 297-309.

[14] McKean, M.A. (1992) "Management of Traditional Common Lands (Iriaichi) in Japan", in D.W. Bromley and D. Feeny (eds.), Making the Commons work, San Francisco: ICS Press, 66-98.

[15] Ostrom, E., Gardner, R., and Walker, J. (1992), "Covenants With and Without Sword: Self-Governance Is Possible", American Political Science Review 86, 404-417.

[16] Ostrom, E., Gardner, R., and Walker, J. (1994), Rules, Games and Common-Pool Resources, Ann Arbor: The University of Michigan Press.

[17] Taylor, L. (1987) "The River would Run Red with Blood: Community and Common Property in Irish Fishing Settlement", in B.J. McCay and J.M. Acheson (eds.), The Question of the Commons: The Culture and Ecology of Communal Resources, Tuscon: University of Arizona Press, 290-307

[18] Vyrastekova, J. and D.P. van Soest (2003), "Centralized Common Pool Management and Local Community Participation", Land Economics 79(4), 500-514.