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# JENA ECONOMIC RESEARCH PAPERS



# 2012 – 004

## **Broken Punishment Networks in Public Goods Games: Experimental Evidence**

by

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**BROKEN PUNISHMENT NETWORKS IN PUBLIC GOODS GAMES:  
EXPERIMENTAL EVIDENCE**

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**Abstract**

Abundant evidence suggests that high levels of contributions to public goods can be sustained through self-governed monitoring and sanctions. This experimental study investigates the effectiveness of decentralized sanctioning institutions where punishment opportunities are restricted to agents who are linked through alternative punishment networks. We find that the structure of the punishment network significantly impacts contributions to the public good, but not overall efficiencies. Contributions collapse over decision rounds in groups with limited punishment opportunities, even if the absolute punishment capacity corresponds to the complete punishment network where all agents are allowed to punish each other. However, after allowing for the costs of sanctions, efficiencies are similar across the different networks that allow for punishment and the no-punishment network.

**Keywords:** public goods experiment, punishment, cooperation, networks.

**JEL-Classification:** C92, D01, D03, H41

## I. INTRODUCTION

There is widespread experimental evidence that the availability of costly peer sanctioning can have a large positive impact on cooperation in social dilemma settings and thus may contribute to the well-functioning of societies (e.g., Ostrom et al. 1992, Fehr and Gächter 2000, Masclet et al. 2003, Walker and Halloran 2004, Sefton et al. 2007). However, this evidence is based primarily on the comparison of two extreme cases; all subjects can punish and be punished by other subjects in the group *versus* a situation where no one can punish. Typically these criteria are not met in the field where punishment opportunities are determined by factors like the physical closeness, endowments, similarity in status, or, more generally, the social network of actors.

Punishment networks, which define who can punish whom, may play a nontrivial role for inducing more efficient provision of public goods or appropriation from common-pool resources. In particular, it seems plausible that more dense punishment networks, where a larger fraction of actors can punish each other, deter actors more effectively from non-cooperative behaviors. This increased deterrence in more dense networks may be associated with the threat of being punished by more agents *and/or* the possibly larger combined punishment capacity. However, it seems equally plausible that more dense punishment networks deter actors less effectively from non-cooperative behaviors if actors believe that the threat of being punished diminishes as the number of potential punishers increases. This is a reasonable conjecture if the second order free-rider problem becomes more severe and effective coordination of punishment becomes more difficult. In addition, the structure of the punishment network may determine agents' willingness to cooperate. For example, contributions and assigned punishments may be reduced if there are agents who cannot be disciplined due to their location outside the punishment network ('untouchables'). Alternatively, such agents may refrain from cooperating because of social preferences, (i.e., conditional cooperation, Fischbacher et al. 2001; inequity-aversion, Fehr and Schmidt 1999; revealed altruism, Cox et al. 2008)

In this paper, we provide new empirical evidence on the role of punishment networks for facilitating cooperation. In a linear public goods experiment, we vary the structure of punishment

networks, the *capacity* by one individual to punish another individual, and the maximum punishment an individual can receive. In our experiment, groups of four agents make contribution and punishment decisions across twenty rounds of repeated play. There are six treatments in this study: (1) a complete punishment network, (2 & 3) pairwise punishment networks with low and high punishment capacity, (4 & 5) untouchable punishment networks with low and high punishment capacity, and (6) a no-punishment network. Treatments 1 and 6 are the two extreme cases on which the literature has focused so far. In the 'pairwise' networks, a group of four is divided in two pairs and punishment can only take place within pairs, although contributions affect the entire group. In the 'untouchable' networks, there are three agents that can punish and be punished by each other and one agent who cannot punish or be punished. We manipulate the individual punishment capacities in these two networks in order to investigate if the observed behavior is driven by the structure of the punishment network or the punishment capacity.

Our findings reveal that the structure of the punishment network significantly affects contributions and punishments, but not economic efficiencies. Varying the capacity for one individual to punish another is found to play a less important role on aggregate contribution levels. Contributions collapse over decision rounds in the pairwise network, even when the capacity to punish one's partner is increased such that the maximum punishment the partner can receive is identical to the complete network. Moreover, contributions are significantly lower in the pairwise network than in the untouchable network and the complete network. In fact, contributions in the pairwise network are statistically indistinguishable from the low contribution levels in the no-punishment network.

The average willingness to punish is least pronounced in the pairwise networks, whereas there is no difference between the untouchable and complete networks. Group efficiencies are very similar across the different punishment networks and the no-punishment network. The reason is that higher contribution levels come at the cost of more pronounced punishment which reduces the incomes of the punishing and punished agents. Finally, we also observe that subjects condition their contributions on subjects in their punishment network and on subjects outside their punishment network (and vice versa).

We contribute to the economics literature testing the effectiveness of various institutional arrangements in social dilemma situations (e.g., Isaac and Walker 1988a&b, Ostrom et al. 1992, Fehr and Gächter 2000, Masclet et al. 2003, Bochet et al. 2006, Anderson and Putterman 2006, Cinyabuguma et al. 2005, Sefton et al. 2007, Egas and Riedl 2008, Gächter et al. 2008, Nikiforakis 2008, Nikiforakis and Norman 2008). While these studies do not explicitly manipulate sanctioning opportunities within the group, they provide insights into the extent to which alternative sanctioning institutions can sustain cooperation in human societies. The majority of these existing studies suggest, much like our study, that different institutional arrangements can have a large positive impact on cooperation, but that the impact on the efficient provision of public goods or appropriation from common-pool resources is rather limited.

This study also connects to an emerging literature examining the role of social and geographic network structures on public good provision. Theoretical investigations (Bramoullé and Kranton 2007) and experimental evidence (Yamagishi and Cook 1993, Fatas et al. 2010) point to the fact that contribution levels may differ significantly across networks. Differences in contributions across such networks are explained by conditionally cooperative responses to the restricted spread of information about individual contributions (Fatas et al. 2010).

Closely related to our study are experiments in which punishment opportunities in public goods settings are manipulated (Carpenter 2007a, O’Gorman et al. 2009, Carpenter et al. 2011). Carpenter (2007a) varies the group size and monitoring opportunities between groups (i.e., information about others contributions and availability to sanction those) and finds that monitoring opportunities determine contribution levels more than group size. O’Gorman et al. (2009) investigate if a solitary punisher in a group can sustain cooperation. They find that contribution levels are similar in a situation where there is only one punisher in a group as compared to a situation where all group members are allowed to punish. A recent paper by Carpenter et al. (2011) uses properties from graph theory to understand the behavior in public goods experiments with eight different monitoring and sanctioning opportunities.

Our study provides first evidence on the relationship between punishment network density, network structure and punishment capacity in public goods settings, and differs in several aspects from

the previous literature. First, we study the bare effect of punishment networks, as we provide complete information about individual contributions, sanctions imposed, and sanctions received for all group members. This contrasts with Carpenter (2007) and Carpenter et al. (2011) who study the joint effect of information dissemination and punishment opportunities in networks where group members do not receive information on individual behavior outside their network. Second, we use a partner-matching protocol with fixed identifiers, while the other studies use a stranger-matching protocol. The advantage of the partner-matching protocol with fixed identifiers is that it captures the essence of networks (i.e., a fixed group of individuals that are linked) and not just the network architecture (i.e., the way a random group of individuals is linked).<sup>1</sup> Third, we control across networks the individual punishment endowments and the total punishment capacity within a group. In the previous studies, the individual punishment endowments are determined by previous contributions to the public good and, thus, total punishment capacities differ systematically across networks. In contrast to these other studies, we are able to identify the role of the punishment network itself and can rule out potential endowment effects. Fourth, we investigate appealing unexplored network structures.

The remainder of the paper is organized as follows. Section II describes the decision setting. Section III presents the experimental results. Section IV contains concluding comments.

## II. THE DECISION SETTING

This study includes data from experimental sessions conducted at Indiana University-Bloomington (U.S.) and the University of East Anglia (U.K.). In each session, 12 to 20 subjects were recruited from subject databases that included undergraduates from a wide range of disciplines. Via the computer, subjects were privately and anonymously assigned to four-person groups and remained in these

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<sup>1</sup> A possible disadvantage is that reputation building is easier in the partner-matching protocol. However, since our primary interest lies in comparing punishment networks and not in disentangling the motivation of individual actors, we believe that the partner-matching protocol is more suited for our purposes. Disentangling the motivation of individual actors in a public goods experiment, even if it uses stranger-matching, is very difficult. First, it is difficult to distinguish between different non-selfish motivations such as inequity-aversion, reciprocity, or spite. Second, other studies show that a substantial fraction of contributions are due to confusion and errors rather than non-selfish motivations (Andreoni 1995).



groups throughout the session. No subject could identify which of the others in the room was assigned to their group. Since no information passed across groups, each session involved 3 to 5 independent groups. At the beginning of each session, subjects privately read a set of instructions, which were then summarized publicly by a member of the research team.<sup>2</sup> Subjects then took a post instruction quiz and were not allowed to continue until all answers were correct. Subjects made all decisions privately.

In our initial set of experiments, there was one treatment condition in which sanctions could not be imposed, the *no-punishment* network, and three treatment conditions that allowed for sanctions: *complete* network, *pairwise* network, and an *untouchable* network. As discussed below, an additional set of experiments were conducted with punishment networks referred to as *pairwise-6* and *untouchable-6* networks. Table 1 presents summary information related to subject groups in each of the conditions. In aggregate, data were collected from 76 four-person groups.<sup>3</sup> Each group participated in a sequence of 20 decision rounds with two stages in each decision round. In the experiments conducted in the U.S., the conversation rate of tokens to dollars was 20 to 1. In the U.K., the conversation of tokens to pounds was 30 to 1.<sup>4</sup>

Stage 1 of each decision round was a linear VCM game. At the beginning of Stage 1, each subject was endowed with ten tokens to be allocated between a private account and a group account. For each token placed in his or her private account a subject received 1 token in payment. For each token placed in the group account, each group member received 0.4 tokens in payment. After all subjects had made their decisions in Stage 1, they were informed of the aggregate allocations to the group account, the allocation of each member of their group to the group account identified by an anonymous ID letter (A, B, C, or D), and their own earnings for the round. Individual decisions were linked to subject identifiers (A, B, C, D)

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<sup>2</sup> See Appendix I for a copy of the instructions. The programs were written using Z-tree (Fischbacher 2007).

<sup>3</sup> Subject's experimental earnings averaged \$22 in the U.S., including a \$5 show-up payment, and £15 in the U.K., including a £3 show-up payment. Experiments lasted from one to one and one half hours.

<sup>4</sup> These differential exchange rates were chosen to create experimental earnings that yielded approximately the same real valued payoffs across locations.

which remained the same during all decision rounds. Thus, unlike many of the earlier decision settings that investigated the use of sanctioning mechanisms, it was feasible for subject-specific reputations to develop across rounds (see Fehr and Gächter 2000, and Sefton et al. 2007). The network treatment conditions are the primary rationale for this particular parameterization. As discussed below, the *pairwise* networks implied that pairs of subjects knew they were linked across decision rounds. The *untouchable* networks implied that one group member could neither receive nor deliver sanctions across rounds.

In Stage 2 of each decision round each subject received an additional endowment of six tokens. Subjects were informed that they would make a decision of whether to decrease the earnings of other members in their group by assigning deduction tokens to them. Each deduction token assigned by a group member to another group member cost the initiator 1 token and decreased the earnings of the recipient by 3 tokens. In our initial set of experiments subjects could assign a maximum of 2 deduction tokens to another group member, reducing that subjects earnings by a maximum of 6 tokens, regardless of the treatment condition. Thus, in the initial set of experiments, the maximum sanction that a subject could *impose* on another subject was held constant across decision rounds, while the maximum number of punishment tokens a subject could *receive* varied across networks.

Any tokens not used to decrease the earnings of other group members were kept in subject's private account. The instructions used neutral language. The term sanctioning was not used. Subjects were told that they would have the opportunity to assign deduction tokens that would reduce the earnings of the subject to whom the tokens were assigned. Following Stage 2 decisions, subjects received information regarding individual group allocations, sanctions imposed, and sanctions received.

Experimental conditions varied only in terms of opportunities for sanctioning defined by the network linkages. In the *complete* network condition, subjects had the opportunity to reduce the earnings of all other group members. In the *paired* network condition, subjects A and B had the opportunity to reduce the earnings of each other, but not C and D. Likewise, subjects C and D had the opportunity to reduce the earnings of each other, but not A and B. In the *untouchable* network condition, subjects A, B, and C had the opportunity to reduce the earnings of each other, but not subject D. Further, subject D did

not have the opportunity to reduce the earnings of any group member (for control purposes, subject D automatically had 6 tokens allocated to their private account).

Figure 1 illustrates our network treatments. As mentioned above, in all treatments information flow was held the same. In particular, every player received information about the contribution and sanction decisions of every other player in his/her group. Only the punishment opportunities depended on the network. An incoming arrow denotes that a player can be punished by the player from whom the arrow originates. An outgoing arrow denotes that a player can punish the receiving group member.

After completing the initial experiments, we conducted an additional set of experiments in the pairwise and untouchable networks, where the maximum number of deductions tokens that a subject could *receive* was equal to that of the *complete* network. This meant that in the pairwise network each subject could impose up to 6 punishment tokens on the subject with whom they were paired. In the untouchable network, the three subjects in the punishment network could impose up to 3 punishment tokens on the other two subjects in their network. Thus, in these additional treatment conditions, subjects in the networks could have their earnings reduced from punishments by a maximum of 18 tokens, the same as in the *complete* network condition. As noted above, we refer to these two networks as *pairwise-6* and *untouchable-6*.

The *no-punishment* network was conducted as a benchmark. Parallel to the approach taken in Sefton et al. (2007), this treatment also contained 2 stages. In Stage 2, however, subjects were simply given an additional 6 tokens which were placed in their private accounts. Otherwise, the treatment was conducted in same manner as the treatments that allowed for sanctioning opportunities.

In all treatment conditions, subjects played a finitely repeated game with a known final round. Under the assumption that it is common knowledge that subjects maximize own-earnings, the theoretical prediction is straightforward. The subgame perfect Nash equilibrium for each treatment condition calls for zero allocations to the group account and no-sanctions.<sup>5</sup> As noted earlier, however, experimental

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<sup>5</sup> In the sanction treatments there are other Nash equilibria, including some that support efficient allocations. However, equilibrium strategies that support efficient allocations rely on non-credible threats to sanction free riders.

studies of the linear VCM game typically find that the level of cooperation observed is not consistent with equilibrium predictions of zero provision of the group good. Moreover, other studies have shown that subjects often pay to sanction other participants when the opportunity is available. However, at the same time subjects react to changes in the price and effectiveness of punishment (Carpenter 2007b), suggesting that players strategically assess the cost and benefits of various sanctioning strategies. At the core of our investigation is the question how network structure and disposable punishment capacities affect these considerations.

### III. RESULTS

We first present the results of the group level analysis which is followed by the results of the individual analysis. We begin with a graphical presentation and summary statistics that focus on group level data across decision rounds in the initial set of network conditions, and follow with a discussion of the *pairwise-6* and *untouchable-6* networks. This descriptive analysis is followed by a more formal regression analysis that incorporates the panel nature of the data. The results presented below pool the data from both experimental sites because the preliminary analyses indicated no significant location effects.

#### Group Level Results

##### *Descriptive Overview*

The discussion of results from the initial treatment conditions focuses on three key outcome variables: 1) tokens allocated to the group account by each four-person group, 2) total tokens used for sanctioning by each four-person group, 3) tokens earned by each group. Figure 2a displays the trajectory of mean group allocations, Figure 2b of sanctions and Figure 2c of earnings for the *complete* networks (mean across 17 groups), the *pairwise* networks (across 14 groups) and the *untouchable* networks (across 15 groups). These are compared to the mean group allocations and earnings for the *no-punishment* networks (across 7 groups). To complement the results displayed in Figures 2 a-c, Table 2 presents the

means and standard deviations of per-round group allocations, group earnings, and sanctions per group, pooled over decision rounds. Trends and differences across treatments noted here are based on cursory observation. We test formally for the significance of these differences using the regression analysis that follows this overview.

In all treatments, average group allocations start at around 50% of the group endowment of 40 tokens. In the *no-punishment* networks, allocations decline over time to levels close to the Nash equilibrium allocation of zero. In the *complete* networks, allocation levels slightly increase and are maintained at around 25 tokens throughout. Group allocations remain steady at around 20 tokens across rounds 1-18 in the *untouchable* networks. However, allocations are always lower than those in the *complete* networks. In sharp contrast, group allocations decline steadily over time in the *pairwise* networks.

Average group sanctions in the *complete* and *untouchable* networks are similar in most rounds and remain steady at around 2.5 tokens per round. In the *pairwise* networks average group sanctions are lower than in the *complete* and the *untouchable* networks in all 20 rounds. In all three networks, there is an increase in sanctions used in the last round. Note that the average level of sanctions imposed is lower than in most studies, in particular Sefton et al. (2007). However, although endowments that could be used for sanctioning were equivalent between our study and Sefton et al. (2007), the opportunity for an individual to sanction another individual was not equivalent. In Sefton et al. (2007), for example, an individual could use his/her full endowment to sanction another individual. In our initial punishment network conditions, subjects were constrained to use no more than 2 tokens in sanctioning another individual

While there are differences in group allocations and sanctioning behavior across the treatments, group earnings display a similar pattern over time. Earnings in the *no-punishment* networks are higher than those in the other three networks in the first few rounds and in the last round. However, between rounds 5 and 19, there is no systematic difference in earnings across network conditions.

Figures 3a-c show the trajectory of mean group allocations (3a), sanctions (3b) and earnings (3c) for the *pairwise* networks and the *pairwise-6* networks. As shown, with only one exception, there are no apparent differences between these network conditions across decision rounds.<sup>6</sup> Figures 4a-c show the trajectory of mean group allocations (4a), sanctions (4b) and earnings (4c) for the *untouchable* networks and the *untouchable-6* networks. As can be seen, group allocations start out higher (around 25) in the *untouchable-6* networks. However, by round 15, there is no discernible difference in allocations. Interestingly, sanctioning is slightly lower in the *untouchable-6* networks in all but 5 rounds. The combination of higher group allocations and lower sanctions across most decision rounds implies that earnings are higher in the *untouchable-6* networks. Figure 4c suggests that this might be the case. Table 2 presents summary statistics on group allocations, sanctions and earnings for these network conditions.

### ***Group-level Regression Analysis***

To examine statistical differences between punishment networks, Tables 3 and 4 present results from panel random effects regression analyses. The dependent variables are group allocations, group sanctions, and group earnings, with dummy variables used to capture treatment and round effects. For all regressions, the unit of observation is group  $g$  in round  $t$  ( $t = 1, 2, \dots, 20$ ). Hence each group in each treatment has 20 observations. In summary for each of the dependent variables (group allocations, group sanctions, and group earnings), the estimated model, with robust standard errors clustered on independent groups, is:

$$\begin{aligned} \text{Dependent Variable}_{gt} = & \alpha + \beta_1 (\text{complete}_g) + \beta_2 (\text{pairwise}_g) + \beta_3 (\text{untouchable}_g) + \\ & \beta_4 (\text{pairwise-6}_g) + \beta_5 (\text{untouchable-6}_g) + \sum \beta_j (\text{round dummies}) + \varepsilon_{gt} \end{aligned}$$

As can be deduced from Table 3, for the regressions on group allocations and group earnings, the omitted “comparison” treatment condition is the *no-punishment* network condition. For the sanctions regression, the omitted comparison treatment condition is the *complete* network condition. For completeness, Table 4

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<sup>6</sup> The exception is in round 7 where sanctions are higher in the *pairwise-6* networks, which leads to lower earnings since there is no difference in group allocations.

provides additional statistical comparisons of coefficient estimates of the treatment dummies, Wald tests, across all treatments pairs that cannot be ascertained from the results presented in Table 3.

The panel level data analysis largely confirms the observations drawn from the overview.<sup>7</sup> We begin with a discussion of our initial three network conditions where we held constant the capacity individuals had to impose sanctions. Relative to the *no-punishment* networks, group allocations are significantly higher in the *complete* networks ( $p = 0.000$ ) and the *untouchable* networks ( $p = 0.017$ ), but not in the *pairwise* networks ( $p = 0.316$ ). Further, group allocations are clearly higher in the *complete* networks than in the *pairwise* networks ( $p = 0.007$ ) and marginally higher than in the *untouchable* networks ( $p = 0.099$ ). There is no significant difference between allocations in the *pairwise* and *untouchable* networks ( $p = 0.191$ ).

**RESULT 1:** The structure of the punishment network can significantly affect allocations to the public good. The network configurations investigated here suggest that broken punishment networks are less effective in increasing public goods contributions.

Turning to punishment, we observe that sanctioning levels are similar in the in the *complete* and *untouchable* networks ( $p = 0.698$ ). However, we also observe that sanctioning levels are significantly lower in the *pairwise* networks as compared to the other two networks (*complete* vs. *pairwise*,  $p = 0.009$ , *untouchable* vs. *pairwise*,  $p = 0.019$ ).

**RESULT 2:** The structure of the punishment network can significantly affect sanctioning levels. Sanctioning levels are lower in the *pairwise* networks than in the *untouchable* and *complete* networks, but there are no differences between the latter two.

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<sup>7</sup> OLS, Tobit and panel random effects models were estimated. The results are qualitatively similar for all the three models. For brevity, only the results of the panel random effects regressions are presented. Estimated coefficients of the round dummies, which reflect the time trends observed in the figures, are not included. We report robust standard errors clustered on independent groups.

Table 3 confirms that there is no statistically significant difference in earnings between the *no-punishment* networks and networks with sanctions (*complete*,  $p = 0.812$ , pairwise,  $p = 0.479$ , *untouchable*,  $p = 0.252$ ). Table 4 confirms that there are no statistically significant differences in earnings across the other network conditions as well.

**RESULT 3:** The structure of the investigated punishment networks does not significantly affect efficiencies. Higher contributions in denser networks come at the cost of higher group sanctions.

To test whether results 1-3 are mainly driven by differences in absolute punishment capacity and not by the structure of the punishment networks, we compare group account allocations, sanctions, and earnings in the *pairwise-6* networks and *untouchable-6* networks to the other networks. First, we compare the *pairwise* networks to the *pairwise-6* networks and then the *untouchable* networks to the *untouchable-6* networks. These comparisons will test whether an increase in the punishment capacity changes behavior holding the network structure constant. Thereafter, we compare the *pairwise-6* networks and the *untouchable-6* networks to the *complete* and *no-punishment* networks.

Tables 3 and 4 provide statistical evidence for the patterns observed in Figures 3 a-c (for the two *pairwise* networks) and Figures 4 a-c (for the two *untouchable* networks). Group allocations are not significantly higher in the *pairwise-6* than in the *pairwise* networks ( $p = 0.597$ ) and in the *untouchable-6* than in the *untouchable* networks ( $p = 0.365$ ). There is no significant difference between group sanctions in the *pairwise-6* and the *pairwise* networks ( $p = 0.358$ ), and in the *untouchable-6* and the *untouchable* networks ( $p = 0.414$ ). Thus, unsurprisingly we also observe little differences in earnings between the *pairwise-6* and the *pairwise* networks ( $p = 0.739$ ) as well as between the *untouchable-6* and the *untouchable* networks ( $p = 0.229$ ).

Despite the identical punishment capacity between the *pairwise-6*, *untouchable-6* and *complete* networks, contributions in the *pairwise-6* networks are significantly lower than in the *complete* networks



( $p = 0.009$ ). Moreover, contributions in the *pairwise-6* networks are also marginally lower than in the *untouchable-6* networks ( $p = 0.089$ ) whereas contributions in the *untouchable-6* networks are similar to contributions in the *complete* networks ( $p = 0.601$ ). Group sanctions in the *pairwise-6* networks and the *untouchable-6* networks are lower than in the *complete* networks but the differences are not statistically significant ( $p = 0.232$  and  $p = 0.264$  respectively). Earnings in the *pairwise-6* networks and the *untouchable-6* networks are statistically indistinguishable from the earnings in the *complete* networks ( $p = 0.583$  and  $p = 0.674$  respectively) and the *no-punishment* networks ( $p = 0.283$  and  $p = 0.785$  respectively).

**RESULT 4:** The structure of the punishment network is more important than the absolute punishment capacity for determining group account allocations, sanctions, and efficiencies.

## Individual Level Results

### *Individual Decisions: Pooling Across All Treatments*

To complement our group level analysis, we turn to an analysis of decisions of individual group members. We begin with a comparison of individual allocations to the group account across treatments. Based on the group level results, we pool the data for the *pairwise* and the *pairwise-6* networks under the heading *combined-pairwise* networks and the data from the *untouchable* and *untouchable-6* networks under *combined-untouchable* networks. Table 5 presents panel random effects estimates from a model incorporating the following explanatory variables: one-period lagged allocation of individual  $i$ , one-period lagged positive deviation of  $i$ 's allocation from the average allocation of the *other* group members, one-period lagged negative deviation of  $i$ 's allocation from the average allocation of the *other* group members and one-period lagged sanctions received (not applicable for the *no-punishment* condition). Also included, but not reported, are round dummy variables.<sup>8</sup>

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<sup>8</sup> We report robust standard errors clustered on independent groups. The results are robust to OLS and Tobit specifications.

We observe that an individual's group allocation in a round is highly influenced by his/her allocation in the previous decision round; in all treatments the previous round's allocation has a similarly significant positive impact on the current allocation (coefficient varies from 0.873 to 0.965;  $p < 0.00$ ). Positive deviations from the average allocation of other group members in the previous round also have a significant negative impact on current allocations and negative deviations from the average allocation others has a positive impact. Table 5 highlights that sanctions received in the previous round have a positive significant impact on current allocations in the *combined-pairwise* and *combined-untouchable* networks ( $p = 0.041$  and  $p = .013$  respectively), but not in the complete networks.

The nature of individual behavior in repeated public goods settings is often characterized as conditional cooperation. In incomplete networks, the network structure and players' positions in the network are likely to influence how they adjust their behavior to that of the other group members. The above regressions do not distinguish between group members who are linked to a particular individual in a group from those in the group who are not linked to that individual. To better understand the effect of changing network structures on the nature of conditional cooperation, the analyses in the two following sections investigate how the network position in the pairwise and untouchable networks impacts group allocations.

### ***Individual Decisions in the Pairwise Networks***

This section focuses on the determinants of individual allocations in the *pairwise* and the *pairwise-6* networks. It is an open question as to whether and to what extent an individual's allocations are influenced by the decisions of the subject that he/she is linked to in the punishment network and by the decisions of the other subjects outside the punishment network. More precisely, subject A in the network might be influenced by the allocation of subject B and vice-versa (similarly for subjects C and D). However, in our experiment, each individual has information on the decisions of *all* others in his/her group. Thus, it is also possible that, within a group, subject A might be influenced by the decisions of subjects C and D even though he/she cannot be sanctioned by either of them.

To control for the linkages across pairs of subjects within groups, Table 6 presents the results from a random effects panel regression of individual allocations in a model incorporating the following explanatory variables: lagged allocation of subject  $i$ , lagged deviation from the subject with whom subject  $i$  is paired in the network, lagged deviation from the mean group allocation of the other pair in the group, lagged sanctions received by  $i$ , and round dummy variables.

The results indicate that both the lagged allocations of one's partner and the lagged average allocation of the other pair significantly influence one's allocation decisions ( $p < 0.001$  for both coefficients) and the magnitudes are similar (coefficients for *pairwise* network are -0.273 and -0.256, respectively and coefficients for the *pairwise-6* network are -0.138 and -0.178 respectively). Thus, it appears that individuals base their decisions on lagged deviations of *all* other group members equally.

Table 6 highlights an additional insight in regard to the effect of received sanctions on allocations to the public good. While the variable *lagged sanctions received* is positive but insignificant when pooling both pairwise networks, this variable is significantly negative in the *pairwise* networks but significantly positive in the *pairwise-6* networks. This results suggests that in the pairwise networks sanctions have a negative impact on contributions when the punishment capacity is small (for every unit of sanctioning received contributions are reduced by 0.418;  $p = 0.014$ ) but a positive impact on contributions when the punishment capacity is large (for every unit of sanctioning received contributions are increased by 0.295;  $p = 0.002$ ). The findings in Table 6 suggest that the relative importance of diminishing contribution levels and adjustment to the mean exceed the threat of being punished during future interactions with the network partner in *pairwise* networks, whereas the greater punishment capacity in *pairwise-6* networks yields a sufficiently high expected punishment in subsequent rounds, leading to increased contributions levels by subjects who have received sanctions.

**RESULT 5:** In two pairwise network conditions, subjects condition their contributions equally on contributions from subjects in and outside their punishment network. Subjects' next round contribution

response to being sanctioned depends on punishment capacity, negative when capacity is low and positive when capacity is high.

### ***Individual Decisions in the Untouchable Networks***

We now focus on individual allocations in the *untouchable* and the *untouchable-6* networks. In these networks, within groups, subjects assigned the positions A, B and C are allowed to sanction each other. Subjects assigned the position D (the *untouchable*) face no threat of receiving sanctions. In the analysis below, we investigate the determinants of the allocation decisions of subjects in the A, B, and C positions separately from those in the D position.

Figures 5a and 5b presents the trajectory of mean allocations and earnings by subjects assigned to the A, B, C and D positions across decision rounds. As shown, there is a pronounced decrease in the pattern of observations for the subjects in the D position, relative to those in the A, B, and C positions. The mean allocation per round by subjects in the A, B and C positions is 5.89 tokens while the mean per round allocation of subjects in the D position is 3.85 tokens ( $n = 26$  groups,  $p = 0.0006$ ). Out of 26 observations on subjects in the D position, 18 of those subjects had mean allocations below those of the other members of their group. Out of the 26 subjects, only one in the D position had a mean group allocation significantly greater than the other subjects in his/her group. Since subjects in the *untouchable* position also do not spend resources on sanctioning, they earn significantly more than the other group members as seen from the second panel of Figure 5. The mean per round earnings of subjects in the A, B and C positions is 15.98 tokens while the mean per round earnings of subjects in the D position is 20.75 tokens ( $n = 26$  groups,  $p = 0.000$ ).

Interestingly, the presence of an *untouchable* does not appear to have a detrimental effect on the willingness to contribute by the other subjects in the same group. There is no significant difference between the mean allocation by subjects in the A, B and C positions (5.89 tokens) in comparison to the mean allocation of subjects in the complete networks of 6.50 tokens ( $n_{\text{complete}} = 17$ ,  $n_{\text{untouchables}} = 26$ ,  $p = 0.498$ ). To examine more closely the factors that influence individual allocations of subjects in the A, B

and C positions, Table 7 reports the results from a random effects panel data regression of individual allocations on: the one-period lagged allocation of individual  $i$ , the one-period lagged deviation of  $i$ 's allocation from the allocation of D, the one-period lagged deviation of  $i$ 's allocation from the average allocation of *the other* members of his punishment network, a one-period lagged variable of sanctions received, and round dummies. In summary, allocations of subjects attached to the punishment networks are significantly influenced by their lagged allocations ( $p < 0.001$ ) and the deviation of their lagged allocations from the average allocations of others in the punishment network ( $p < 0.001$ ). In addition, their allocations are also negatively influenced by the deviation of their lagged allocations from the allocation of the untouchable ( $p < 0.001$ ) suggesting that the untouchable can trigger higher contributions of the subjects in the punishment network. Finally, much like in the pairwise networks, we observe that the punishment capacity determines whether receiving sanctions has a negative (if capacity is small) or positive (if capacity is large) impact on contributions.

Table 8 presents random effects estimates for the determinants of the allocations of subjects assigned to the untouchable position, D, on the one-period lagged allocation of individual  $i$ , the one-period lagged deviation of  $i$ 's allocation from the average allocation of others in the same group, and round dummies. As shown, the allocations of the subjects in the untouchable position are mostly influenced by lagged allocations. The variable, lagged deviation from mean allocations of other subjects in the group, is negative for both untouchable networks and highly significant when pooling data from the *untouchable* and *untouchable-6* networks ( $p = 0.009$ ). In summary, mean group allocations and earnings of the subjects in the untouchable position follow a trajectory that is similar to the others subjects in their groups, except that the level of group allocations is lower and earnings are higher.

**RESULT 6:** Subjects in the untouchable position exploit the situation by contributing less to the group account; but they condition their behavior on allocations of the other subjects in their group. Subjects in groups with an untouchable are able to sustain high levels of contributions, although they condition their behavior on all other subjects in their group, including the untouchable.

### ***Patterns of Sanctioning Behavior***

Pooling across treatments and observations within the specified intervals, Figure 6 shows the relationship between average sanctions received by individuals and the deviation of their group allocation from the average allocations of others in their punishment network.<sup>9</sup> The figure also reports the amount of sanctions imposed within each interval. In the *complete* networks, we measure deviations from the average allocation of the other three individuals in a group, in the *pairwise* networks, the deviation between an individual's allocation and that of the individual who is his network partner, and in the *untouchable* networks, the deviation from the average allocation of the other two individuals in the sanctioning network.

The pattern of sanctioning behavior is similar to that observed in other studies (e.g., Sefton et. al. 2007); i.e., mean sanctions received are larger when a subject's allocation is further below the average allocation of others. There is also evidence of "revenge", i.e., some subjects are sanctioned even when their allocations are above the mean of others. In previous studies, this behavior was referred to as "blind revenge." Here, due to the information individuals have regarding the identity of others, the behavior is clearly not "blind."

For a more formal analysis, Table 9 presents the results from two random effects regressions on sanctions received, one focusing on instances of negative deviations and the other on positive deviations. Sanctions received are regressed on the absolute value of negative or positive (including 0) deviation from the average contribution of the others in the individual's punishment network, treatment dummies, group dummies and round dummies. The omitted treatment is the *complete* network. For the sake of brevity, the coefficient estimates of the group and round dummies are not reported. The regressions

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<sup>9</sup> Computing the average sanction for each category includes both sanctions imposed and instances in which a sanction was not imposed.

confirm the trends observed in the Figure 6. Greater negative deviations are penalized more heavily. Positive deviations are penalized, but there is no strong trend associated with the magnitude of deviations. The coefficients for treatment dummies in the regression for negative deviations are also revealing. The coefficients of the dummy variables for the *pairwise* and *pairwise-6* networks are negative and significant; indicating that sanctioning of individuals with larger negative deviations from others within the sanctioning network was less aggressive than in the *complete* networks. The coefficients of the dummy variables for the *untouchable* and *untouchable-6* networks are positive and significant; indicating that sanctioning was more aggressive than in the *complete* networks.

Finally, we also examined the relationship between sanctions imposed and the group allocations of those that sanction. Similar to past studies, there is ample evidence that those who sanction to the greatest extent tend to be those individuals with group allocations greater than the average of other group members. In support of the observation that there appears to be sanctioning aimed at revenge, we also find sanctioning by those who contribute below the average of other group members, although the average sanction imposed by this group is considerably smaller than the average sanction imposed by those who allocate above the mean contribution.

**RESULT 7:** Similar to other studies, sanctions imposed are strongly correlated with negative deviations in contributions from contributions of other group members. Sanctions assigned are most strongly associated with individuals who allocate more to the group account than other group members. There is also evidence of sanctioning used for purposes of revenge.

#### IV. CONCLUDING COMMENTS

This study contributes to the literature on sanctioning behavior in social dilemma settings by examining the influence of alternative linkages between subjects that restrict the directional flow of endogenously imposed sanctions, as well as the capacity to sanction at the individual and group level. More specifically, our design investigates the capacity to sanction individuals in the network, as well as

the capacity to be sanctioned. Flow of information within the networks is controlled by allowing for complete information among all individuals in a group regarding individual group allocations, sanctions imposed, and sanctions received.

In comparison to the *no-punishment* networks, the *complete* networks and the *untouchable* networks lead to greater allocations to the group good. The *pairwise* networks, however, do not lead to greater allocations than observed in the *no-punishment* network. Importantly, there are important treatment effects across the punishment networks. Group allocations are higher in the *complete* networks in comparison to the *pairwise* and *untouchable* networks. However, because the increase in the level of group allocations is not sufficient to overcome the costs of imposed sanctions, the net result is no difference in earnings across the various network conditions.

In order to examine the relative influence of network conditions and total punishment capacity, experiments are also conducted in which the maximum potential to sanction is held constant at the individual subject level in some network conditions and at the group level in others. The results regarding group allocations and earnings are robust to these two conditions.

Asymmetric power in the *untouchable* network condition is shown to greatly influence the contribution patterns and income distributions across actors. The asymmetric possibility to free-ride at the costs to others, with no possibility of being sanctioned, leads to a situation where contributions by the *untouchable* are below the group average contributions of those in the punishment network

Our results may have implications for public policy and organizational thinking related to the pervasive conflict of individual interest and collective efficiency. In a world of inherent asymmetries in information, monitoring, and sanctioning networks, a proper understanding of group structures and how individual actors connect to each other is crucially important when trying to understand the nature of voluntary cooperation. This study suggests that incomplete linkages between actors may be most important in the extreme case of subgroups who are completely insulated from sanctioning and that the existence of incomplete linkages may be more important than the overall capacity to sanction. This result



raises the question of whether and how collective action groups in the field can develop institutions or social norms to overcome such asymmetries.

As far as can be deduced from our experimental setup, our study points to the potential dangers of implementing unbalanced economic unions or international agreements with detached actors who nevertheless profit from the provided collective good. Potential policy interventions and institutional designs based on sanctions need to pay close attention to the group's underlying network structure in order to avoid creating unnecessary temptations to free-ride on the costs of others contributions as manifested in our *untouchable* network condition. The potential economic message of our study appears to be notable in an era of global commons and economic unification.

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**Table 1 - Design Information for Network Conditions**

<b>Network Condition</b>	<b>Number of Groups U.S.</b>	<b>Number of Groups U.K.</b>	<b>Total Number of Independent Groups</b>
<i>No-punishment</i>	7	0	7
<i>Complete</i>	9	8	17
<i>Pairwise</i>	6	8	14
<i>Untouchable</i>	8	7	15
<i>Pairwise-6</i>	12	0	12
<i>Untouchable-6</i>	11	0	11

**Table 2 - Summary Statistics: Group Level Data**

	<b>Mean Group Allocation (standard deviation)</b>	<b>Mean Punishment (standard deviation)</b>	<b>Mean Earnings (standard deviation)</b>
<i>No-punishment</i> (7 groups)	10.629 (8.744)	-	70.377 (5.246)
<i>Complete</i> (17 groups)	26.017 (11.878)	2.532 (1.922)	69.481 (13.714)
<i>Pairwise</i> (14 groups)	14.942 (11.406)	1.153 (1.0098)	68.351 (8.308)
<i>Untouchable</i> (15 groups)	19.92 (9.365)	2.293 (1.622)	66.779 (9.979)
<i>Pairwise-6</i> (12 groups)	16.867 (7.456)	1.696 (1.878)	67.337 (7.612)
<i>Untouchable-6</i> (11 groups)	23.691 (11.740)	1.732 (1.885)	71.287 (9.490)

**Table 3 – Group Allocations, Punishment and Earnings**

	Dependent Variable		
	Group Allocations	Group Punishment	Group Earnings
<i>Complete</i>	15.389*** (4.205)	.....	-0.896 (3.767)
<i>Pairwise</i>	4.314 (4.304)	-1.379*** (0.530)	-2.026 (2.861)
<i>Untouchable</i>	9.291** (3.906)	-0.239 (0.617)	-3.598 (3.139)
<i>Pairwise-6</i>	6.238* (3.743)	-0.837 (0.699)	-3.040 (2.833)
<i>Untouchable-6</i>	13.062*** (4.623)	-0.801 (0.717)	0.910 (3.337)
Constant	13.106*** (3.121)	2.793*** (0.472)	70.916*** (2.101)
Obs. [cluster/groups]	1520 [76]	1380 [69]	1520 [76]
<p>For regressions 1 and 3, there are 76 groups with 20 observations each (<math>N = 76 * 20 = 1520</math>). For regression 2, there are 69 groups with 20 observations each (<math>N = 69 * 20 = 1380</math>).</p> <p>For the analysis on group allocations and group earnings, the reference category is the <i>No-punishment</i> network. For the analysis of group punishment, the reference category is the <i>Complete</i> network.</p> <p>Figures in parentheses are robust standard errors clustered on independent groups                      *** sig. at 1%, ** sig. at 5%, * sig. at 10%</p>			

Table 4 - Wald Tests ( $\chi^2$  statistics) and p-values for Equality of Coefficient Estimates

<b>Group Allocations</b>	Complete Network	Pairwise Network	Untouchable Network	Pairwise-6 Network
<i>Pairwise</i>	7.25*** (0.007)	-	-	-
<i>Untouchable</i>	2.72* (0.099)	1.71 (0.191)	-	-
<i>Pairwise-6</i>	6.74*** (0.009)	0.28 (0.597)	0.93 (0.334)	-
<i>Untouchable-6</i>	0.27 (0.601)	3.71* (0.054)	0.82 (0.365)	2.89* (0.089)
<b>Group Punishment</b>	Complete Network	Pairwise Network	Untouchable Network	Pairwise-6 Network
<i>Untouchable</i>	-	5.44** (0.019)	-	-
<i>Pairwise-6</i>	-	0.85 (0.358)	0.80 (0.372)	-
<i>Untouchable-6</i>	-	0.90 (0.344)	0.67 (0.414)	0.00 (0.962)
<b>Group Earnings</b>	Complete Network	Pairwise Network	Untouchable Network	Pairwise-6 Network
<i>Pairwise</i>	0.08 (0.774)	-	-	-
<i>Untouchable</i>	0.43 (0.513)	0.22 (0.637)	-	-
<i>Pairwise-6</i>	0.30 (0.583)	0.11 (0.739)	0.03 (0.867)	-
<i>Untouchable-6</i>	0.18 (0.674)	0.70 (0.404)	1.45 (0.229)	1.28 (0.258)
Figures in parentheses are p-values. *** sig. at 1%, ** sig. at 5%, * sig. at 10%				

**Table 5 - Individual Allocations across Treatments**

	<b>Dependent Variable: Individual Allocations</b>			
	<b>No-Punishment Network</b>	<b>Complete Network</b>	<b>Combined Pairwise Networks</b>	<b>Combined Untouchable Networks</b>
Lagged allocation of <i>i</i>	0.889*** (0.056)	0.961*** (0.013)	0.947*** (0.015)	0.913*** (0.019)
Lagged positive deviation from mean allocation of others in group	-0.536*** (0.106)	-0.376*** (0.058)	-0.617*** (0.078)	-0.495*** (0.053)
Lagged absolute negative deviation from mean allocation of others in group	0.385*** (0.038)	0.313** (0.137)	0.181*** (0.065)	0.176*** (0.067)
Lagged punishment received	-	-0.141 (0.098)	0.191** (0.093)	0.224** (0.090)
Constant	1.736** (0.731)	1.318*** (0.373)	1.115*** (0.342)	1.240*** (0.361)
Observations [groups]	532 [7]	1292 [17]	1976 [26]	1976 [26]
Figures in parentheses are robust standard errors clustered on independent groups *** sig. at 1%, ** sig. at 5%, * sig. at 10%				

**Table 6 - Individual Allocations in the Pairwise and the Pairwise-6 Networks**

	<b>Dependent Variable: Individual Allocations</b>		
	<b>Pairwise Network</b>	<b>Pairwise-6 Network</b>	<b>Combined Pairwise Networks</b>
Lagged allocation of <i>i</i>	0.944*** (0.019)	0.916*** (0.021)	0.939*** (0.015)
Lagged deviation from paired subject in network	-0.273*** (0.024)	-0.138*** (0.028)	-0.198*** (0.026)
Lagged deviation from mean allocation of other pair in group	-0.256*** (0.056)	-0.178*** (0.049)	-0.222*** (0.040)
Lagged punishment received	-0.418** (0.170)	0.295*** (0.093)	0.089 (0.094)
Constant	0.629*** (0.216)	0.484 (0.426)	0.436** (0.220)
Observations [groups]	1064 [14]	912 [12]	1976 [26]
Figures in parentheses are robust standard errors clustered on independent groups *** sig. at 1%, ** sig. at 5%, * sig. at 10%			



**Table 7 - Individual Allocations (A,B,C): Untouchable and Untouchable-6 Networks**

<b>Dependent Variable: Individual Allocations – Persons A,B,C</b>			
	<b>Untouchable Network</b>	<b>Untouchable-6 Network</b>	<b>Combined Untouchable Networks</b>
Lagged allocation of <i>i</i>	0.930*** (0.031)	0.948*** (0.036)	0.946*** (0.021)
Lagged deviation from allocation of Person D	-0.088*** (0.021)	-0.102** (0.049)	-0.101*** (0.022)
Lagged deviation from mean allocation of others in punishment network	-0.408*** (0.035)	-0.395*** (0.105)	-0.402*** (0.042)
Lagged punishment received	-0.215* (0.117)	0.113 (0.103)	-0.073 (0.089)
Constant	0.298 (0.579)	1.410*** (0.417)	0.712* (0.371)
Observations [groups]	855 [15]	627 [11]	1482 [26]
Figures in parentheses are robust standard errors clustered on independent groups *** sig. at 1%, ** sig. at 5%, * sig. at 10%			

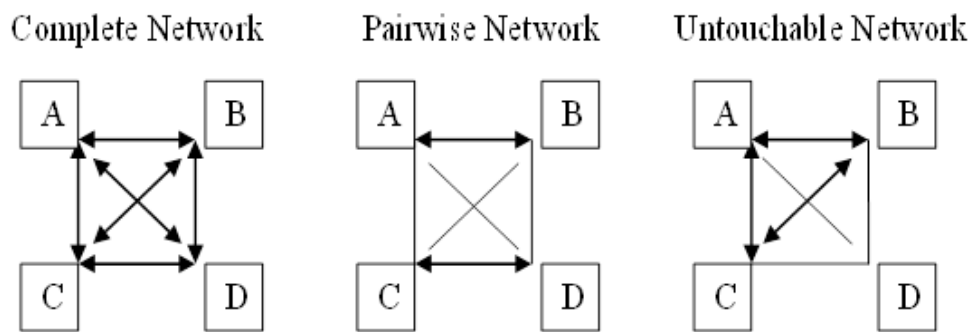
**Table 8 - Individual Allocations (D): Untouchable and Untouchable-6 Networks**

<b>Dependent Variable: Individual Allocations Person D</b>			
	<b>Untouchable Network</b>	<b>Untouchable-6 Network</b>	<b>Combined Untouchable Networks</b>
Lagged allocation of i	0.813*** (0.108)	0.869*** (0.072)	0.831*** (0.066)
Lagged deviation from mean allocation of A, B, C in group	-0.133 (0.086)	-0.212* (0.121)	-0.178*** (0.068)
Constant	2.664*** (0.938)	-1.054 (1.379)	1.088 (0.818)
Observations [groups]	285 [15]	209 [11]	494 [26]
Figures in parentheses are robust standard errors clustered on independent groups *** sig. at 1%, ** sig. at 5%, * sig. at 10%			

**Table 9 - Determinants of Punishment Received by Individuals**

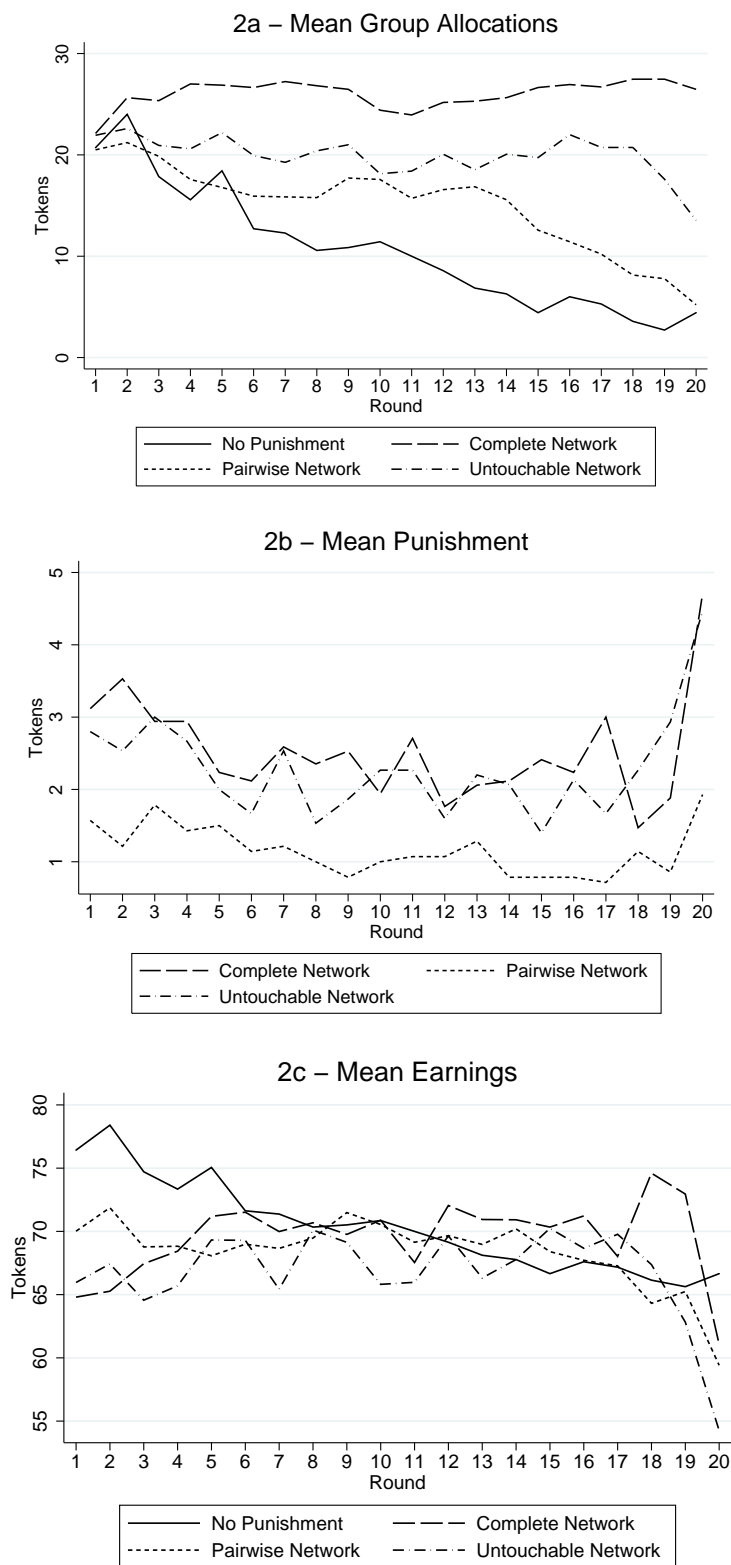
<b>Dependent Variable: Individual Punishment Received</b>		
	<b>Negative Deviations</b>	<b>Positive Deviations</b>
Absolute value of negative deviations	0.218*** (0.023)	-
Absolute value of positive deviations	-	0.019** (0.008)
<i>Pairwise</i>	-0.389*** (0.075)	-0.127*** (0.009)
<i>Untouchable</i>	0.462*** (0.087)	-0.065*** (0.023)
<i>Pairwise-6</i>	-0.819*** (0.065)	-0.246*** (0.016)
<i>Untouchable-6</i>	1.938*** (0.062)	0.019 (0.017)
Constant	-0.209 (0.205)	0.259*** (0.069)
Observations [groups]	1566 [68]	3434 [69]
Figures in parentheses are robust standard errors clustered on independent groups *** sig. at 1%, ** sig. at 5%, * sig. at 10%		

**Figure 1 – Punishment Networks**

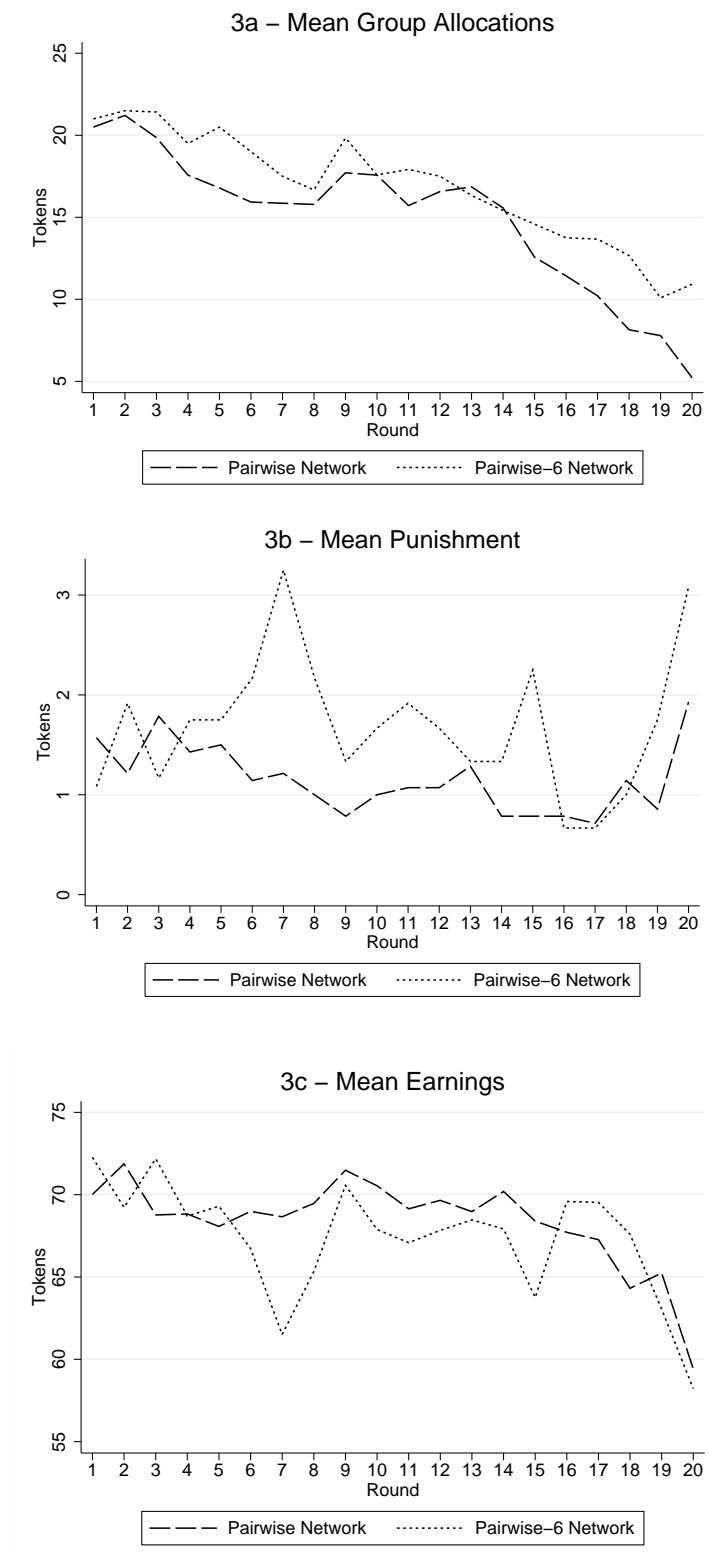


Notes: In all treatments information flow was held the same, indicated by the lines between players. Every player received information about the contribution and punishment decisions of every other player in her group. Only the punishment opportunities depended on the network. An incoming arrow denotes that a player can be punished by the player from whom the arrow originates. An outgoing arrow denotes that a player can punish the receiving group member

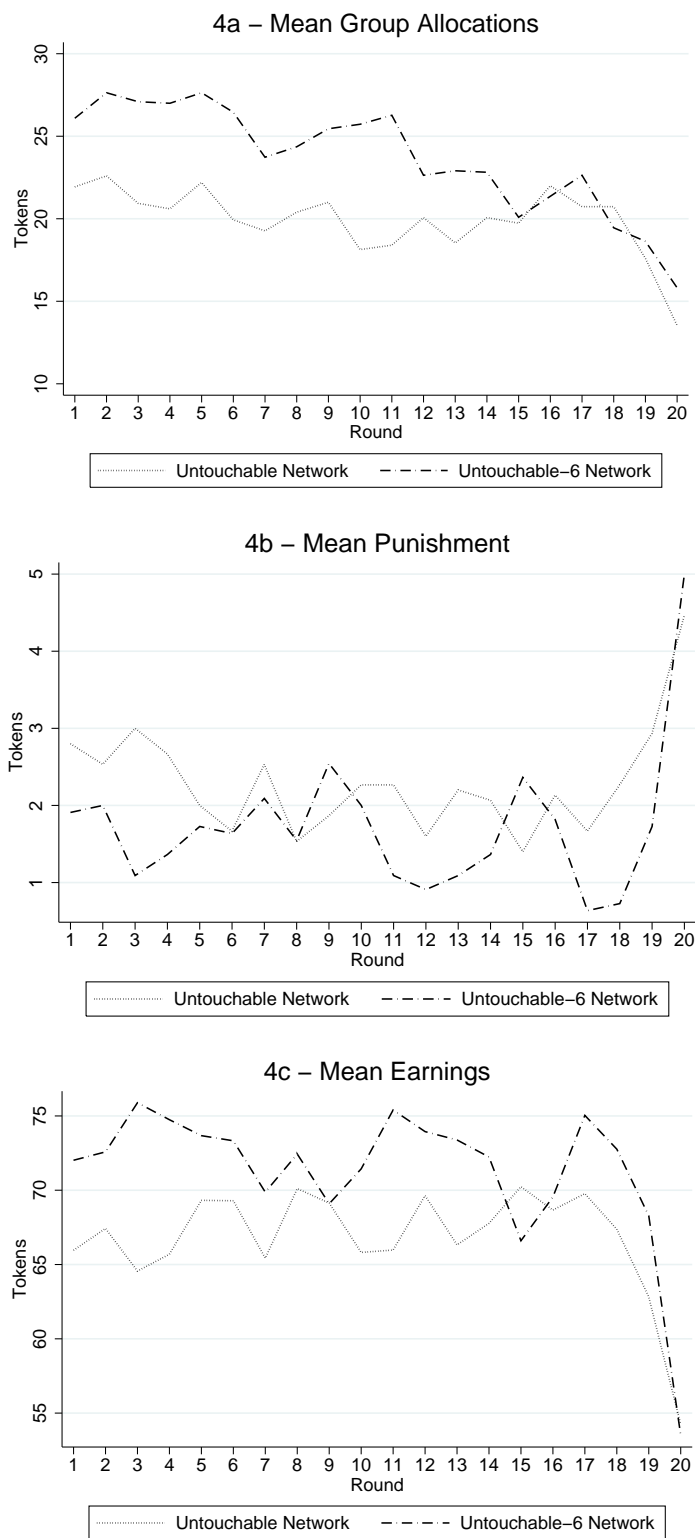
Figures 2a-c - Allocations, Punishment and Earnings: Initial Punishment Networks



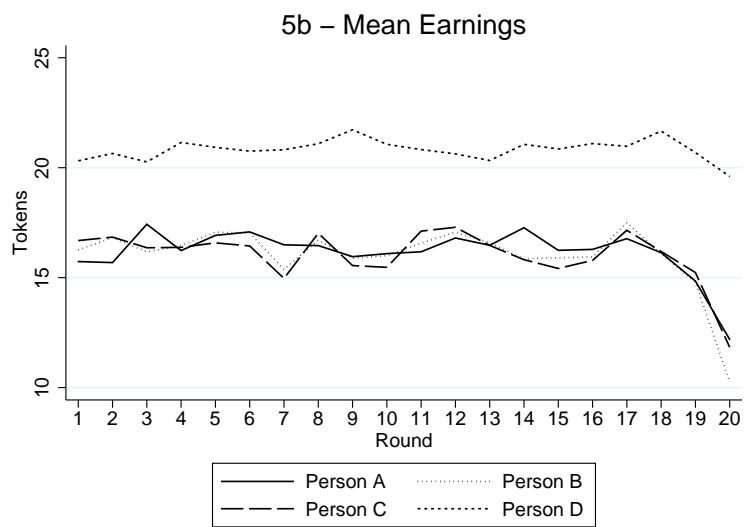
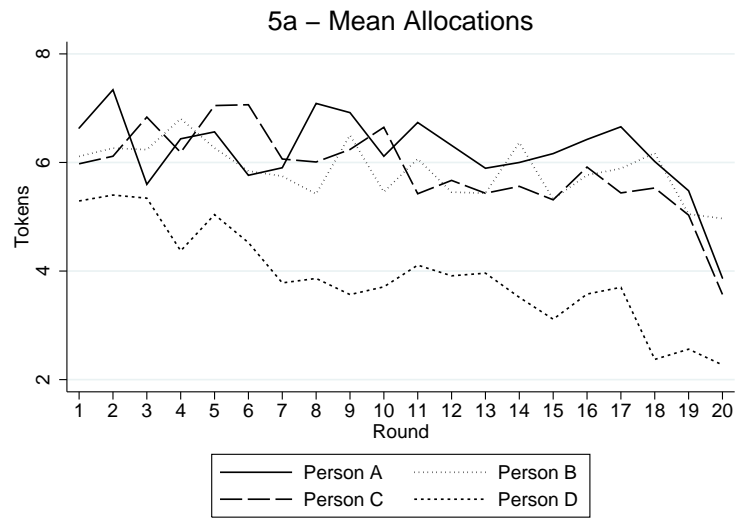
Figures 3a-c - Allocations, Punishment and Earnings: Pairwise and Pairwise-6 Networks



Figures 4a-c - Allocations, Punishment and Earnings: Untouchable and Untouchable-6 Networks

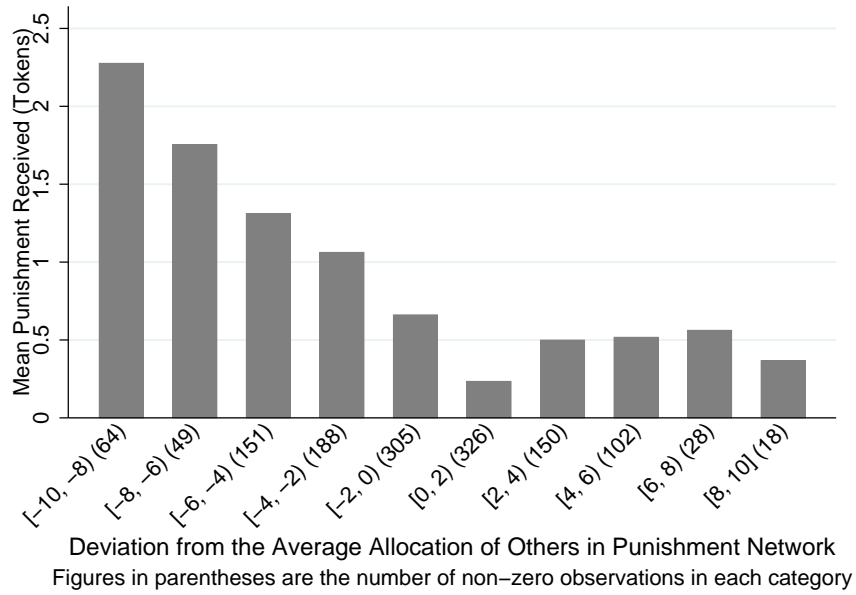


Figures 5a-b - Allocations and Earnings by Network Position: Combined Untouchable Networks





**Figure 6 - Mean Punishment Received by Individuals**



## **Appendix 1 – Instructions for the Complete Network**

Thank you for coming! This is an experiment about decision-making. You will receive \$5 for showing up on time. If you follow the instructions carefully, you can earn more money depending both on your own decisions and on the decisions of others.

These instructions and your decisions in this experiment are solely your private information. During the experiment you are not allowed to communicate with any of the other participants or with anyone outside the laboratory. Please switch off your mobile phone now. If you have any questions at any time during the course of this experiment, please raise your hand. An experimenter will assist you privately.

**The experiment consists of twenty (20) consecutive decision rounds.** Your total earnings will be the sum of your earnings from all these rounds.

**At the beginning of the experiment, participants will be randomly divided into groups of four (4) individuals.** The composition of the groups will remain the same in each round. This means that you will interact with the same people in your group throughout the experiment. For record keeping purposes, the computer will randomly assign each individual in a group an ID letter, either A, B, C or D. You, and each of the other group members, will have the same ID for the rest of this experiment. Thus, if you are assigned to be individual A in your group, your ID will be A in all 20 decision rounds.

This experiment is structured so that the other participants will never be informed about your personal decisions or earnings from the experiment. You will record your decisions privately at your computer terminal. You will be paid individually and privately in cash at the end of the experiment.

During the experiment all decisions and transfers are made in tokens (more details below). Your total earnings will also be calculated in tokens and, at the end of the experiment will be converted to Dollars at the following rate:

$$\mathbf{20\ tokens = \$1}$$

### **First Stage of each round**

You are a member of a group of four participants. At the beginning of each round, each member is endowed with **10 tokens**. **Your task is to allocate them fully or partially either into your private account or to a group account.** Each token not allocated to the group account will automatically remain

in your private account. Your total earnings include earnings from both your private account and the group account. All participants in your group will simultaneously face the same decision situation.

**Your earnings from the private account in each round**

**You will earn one (1) token for each token allocated to your private account.** No other member in your group will earn from your private account.

**Your earnings from the group account in each round**

**For each token you allocate to the group account, you will earn 0.4 tokens. Each of the other three people in your group will also earn 0.4 tokens. Thus, the allocation of 1 token to the group account yields a total of 1.6 tokens for all of you together.** Your earnings from the group account are based on total number of tokens invested by all members in your group. Each member will profit equally from the amount allocated to the group account. For each token allocated to the group account, each group member will earn 0.4 tokens regardless of who made the allocation. This means that you will earn from your own allocation as well as from the allocations of others.

**Your total earnings in Stage 1 in each round**

Your total earnings consist of earnings from your private account *and* the earnings from the group account.

**Your earnings in Stage 1 = Earnings from your private account + Earnings from the group account**

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**The following examples are for illustrative purposes only.**

**Example 1.** Assume that you have allocated 0 tokens to the group account. Suppose that each of the other group members has also allocated 0 tokens to the group account. Thus the total number of tokens in the group account in your group is 0. Your earnings from Stage 1 of this round will be 10 tokens (10 tokens from your private account and 0 tokens from the group account). The earnings of the other group members in Stage 1 of this round will be 10 tokens each.

**Example2.** Assume that you have allocated 5 tokens to the group account. Suppose that each of the other group members has allocated 0 tokens to the group account. Thus the total number of tokens in the group account in your group is 5. Your earnings from Stage 1 of this round will be 7 tokens (= 5 tokens from your private account and  $5 * 0.4 = 2$  tokens from the group account). The earnings of the other group members from Stage 1 of this round will be 12 tokens (= 10 tokens from the private account +  $5 * 0.4 = 2$  tokens from the group account) each.

**Example3.** Assume that you have allocated 10 tokens to the group account. Suppose that each of the other group members has also allocated 10 tokens to the group account. Thus the total number of tokens in the group account in your group is 40. Your earnings from Stage 1 of this round will be 16 tokens (= 0 tokens from your private account and  $40 * 0.4 = 16$  tokens from the group account). The earnings of the other group members will similarly be 16 tokens each.

### **Second Stage of each round**

After all individuals have made their decisions in the first stage, the computer will tabulate the results. You will be informed of the total allocation to the group account and the individual allocation decisions of each group member. Group members will be identified by their IDs, which will remain the same in each round. Group members will be listed alphabetically by their IDs.

**In the second stage, each person will receive an additional endowment of six tokens. You will now make a decision whether to decrease the earnings of other members in your group by assigning deduction tokens to them. Each deduction token you assign to another group member costs you 1 token and will decrease the earnings of that group member by 3 tokens.** You can assign a maximum of 2 deduction tokens to any group member. If you do not want to change the earnings of a specific group member, you will assign a 0 to that group member. **Any tokens not used to decrease the earnings of other group members will be kept in your private account.** You will earn 1 token for each token kept in your private account.

*To which group member you can assign deduction tokens depends on your ID letter as detailed below. Your ID letter also determines who can assign deduction tokens to you.*

**Person A** can assign deduction tokens to persons B, C and D. For each of the other three group members, you will decide how many deduction tokens to assign him/her. The maximum number of deduction tokens you can assign to persons B, C and D is 2 each.

**Person B** can assign deduction tokens to persons A, C and D. For each of the other three group members, you will decide how many deduction tokens to assign him/her. The maximum number of deduction tokens you can assign to persons A, C and D is 2 each.

**Person C** can assign deduction tokens to persons A, B and D. For each of the other three group members, you will decide how many deduction tokens to assign him/her. The maximum number of deduction tokens you can assign to persons A, B and D is 2 each.

**Person D** can assign deduction tokens to persons A, B and C. For each of the other three group members, you will decide how many deduction tokens to assign him/her. The maximum number of deduction tokens you can assign to persons A, B and C is 2 each.

Notice that due to the varying possibilities to assign deduction tokens to other group members, the prospect of receiving deduction tokens differs according to the ID letter. The following illustration clarifies the interaction structure at the second decisions stage. An outgoing arrowhead means that you can assign up to 2 deduction tokens to the receiving group member. An incoming arrowhead means that you can be assigned up to 2 deduction tokens by the group member from whom the arrow originates.

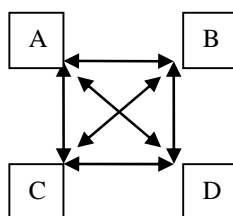


Figure1. Illustration of the interaction structure in the second stage

For instance, consider person A in Figure 1. An outgoing arrow from A to B means that person A can assign up to 2 deduction tokens to person B. An incoming arrow from D to A means that person A can be assigned up to 2 deduction tokens by person D.

**Your total earnings in Stage 2 in each round**

**Your earnings in Stage 2 = 6**

- Total number of deduction tokens used by you

- 3 \* Total number of deductions tokens assigned to you by other group members

To summarize, your total earnings from each round will be calculated as follows:

**Your total earnings in each round =**

**Earnings from the first stage (in TOKENs) +**

**Earnings from the second stage (in TOKENs)**

After all participants have made their decisions in the first and second decision stage, the number of tokens you earned in the corresponding round will be displayed to you and stored in the computer. Notice that your total calculated earnings in tokens at the end of a decision round can be negative if the costs from assigned and received deduction tokens exceed your combined earnings from the first stage and tokens kept in the individual account in the second stage.

Your earnings from earlier rounds cannot be used in the following rounds. You will receive a new endowment for the first and second decision stage in each round. The same process will be repeated for a total of 20 rounds. If your cumulative earnings from all 20 rounds at the end of the experiment are negative, the computer will automatically record zero earnings for you from the experiment. Thus, while your earnings from any particular round can be negative, your earnings from the experiment CANNOT be negative.

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At any time, a history table with a summary of decisions and earnings in the previous round will be available. For each group member, the table will report the number of tokens he/she allocated to the group account in the first stage. In addition, the table will also report the number of deduction tokens assigned by a group member to every other group member. Finally, the table will also report the total number of deduction tokens received, earnings from the round and total cumulative earnings for each group member. Once again, the group members will be listed alphabetically by their ID letters. Figure 2 below presents the history table you will see.

**Your ID letter is:**

ID Letter	Tokens allocated to group account (out of 10)	Deduction tokens received from:				Total deduction tokens received	Earnings Reduction (tokens)	Earnings in previous round (tokens)	Total earnings (tokens)
		A	B	C	D				
A		-							
B			-						
C				-					
D					-				

Figure 2: Table with summary of decisions and earnings from the previous round

To see the history screen, click the 'History of previous round' button at the bottom of your screen. To continue, you must click the 'Return' button.

### Questions to help you better understand the decision tasks

When everyone has finished reading the instructions, and before the experiment begins, we will ask you a few questions regarding the decisions you will make in the experiment. The questions will help you understand the calculation of your earnings and ensure that you have understood the instructions.

Please answer these questions on your computer terminal. Please type your answer in the box next to the corresponding question. Once you have answered all questions correctly we will begin the experiment.

## Instructions for Paired Network Related to Stage 2

### Second Stage of each round

After all individuals have made their decisions in the first stage, the computer will tabulate the results. You will be informed of the total allocation to the group account and the individual allocation decisions of each group member. Group members will be identified by their IDs, which will remain the same in each round. Group members will be listed alphabetically by their IDs.

**In the second stage, each person will receive an additional endowment of six tokens. You will now make a decision whether to decrease the earnings of other members in your group by assigning deduction tokens to them. Each deduction token you assign to another group member costs you 1 token and will decrease the earnings of that group member by 3 tokens.** You can assign a maximum of 2 deduction tokens to any group member. If you do not want to change the earnings of a specific group member, you will assign a 0 to that group member. **Any tokens not used to decrease the earnings of other group members will be kept in your private account.** You will earn 1 token for each token kept in your private account.

*To which group member you can assign deduction tokens depends on your ID letter as detailed below. Your ID letter also determines who can assign deduction tokens to you.*

**Person A** can assign deduction tokens to person B alone. You will decide how many deduction tokens to assign person B. The maximum number of deduction tokens you can assign to persons B is 2. Four tokens out of your endowment of 6 tokens will automatically be transferred to your private account.



**Person B** can assign deduction tokens to person A alone. You will decide how many deduction tokens to assign person A. The maximum number of deduction tokens you can assign to persons A is 2. Four tokens out of your endowment of 6 tokens will automatically be transferred to your private account.

**Person C** can assign deduction tokens to person D alone. You will decide how many deduction tokens to assign person D. The maximum number of deduction tokens you can assign to persons D is 2. Four tokens out of your endowment of 6 tokens will automatically be transferred to your private account.

**Person D** can assign deduction tokens to person C alone. You will decide how many deduction tokens to assign person C. The maximum number of deduction tokens you can assign to persons C is 2. Four tokens out of your endowment of 6 tokens will automatically be transferred to your private account.

Notice that due to the varying possibilities to assign deduction tokens to other group members, the prospect of receiving deduction tokens differs according to the ID letter. The following illustration clarifies the interaction structure at the second decisions stage. An outgoing arrowhead means that you can assign up to 2 deduction tokens to the receiving group member. An incoming arrowhead means that you can be assigned up to 2 deduction tokens by the group member from whom the arrow originates.

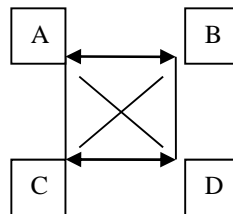


Figure 1. Illustration of the interaction structure in the second stage

For instance, consider person A in Figure 1. An outgoing arrow from A to B means that person A can assign up to 2 deduction tokens to person B. An incoming arrow from C to A means that person A can be assigned up to 2 deduction tokens by person C.

## **Instructions for Untouchable Network related to Stage 2**

### **Second Stage of each round**

After all individuals have made their decisions in the first stage, the computer will tabulate the results. You will be informed of the total allocation to the group account and the individual allocation decisions of each group member. Group members will be identified by their IDs, which will remain the same in each round. Group members will be listed alphabetically by their IDs.

**In the second stage, each person will receive an additional endowment of six tokens. You will now make a decision whether to decrease the earnings of other members in your group by assigning deduction tokens to them. Each deduction token you assign to another group member costs you 1 token and will decrease the earnings of that group member by 3 tokens.** You can assign a maximum of 2 deduction tokens to any group member. If you do not want to change the earnings of a specific group member, you will assign a 0 to that group member. **Any tokens not used to decrease the earnings of other group members will be kept in your private account.** You will earn 1 token for each token kept in your private account.

*To which group member you can assign deduction tokens depends on your ID letter as detailed below. Your ID letter also determines who can assign deduction tokens to you.*

**Person A** can assign deduction tokens to persons B and C. For each of these two group members, you will decide how many deduction tokens to assign him/her. The maximum number of deduction tokens you can assign to persons B and C is 2 each. Two tokens out of your endowment of 6 tokens will automatically be transferred to your private account.

**Person B** can assign deduction tokens to persons C and A. For each of these two group members, you will decide how many deduction tokens to assign him/her. The maximum number of deduction tokens you can assign to persons C and A is 2 each. Two tokens out of your endowment of 6 tokens will automatically be transferred to your private account.

**Person C** can assign deduction tokens to persons A and B. For each of these two group members, you will decide how many deduction tokens to assign him/her. The maximum number of deduction tokens you can assign to persons A and B is 2 each. Two tokens out of your endowment of 6 tokens will automatically be transferred to your private account.

**Person D** can NOT assign deduction tokens to anyone. Your entire endowment of 6 tokens will be transferred to your private account.

Notice that due to the varying possibilities to assign deduction tokens to other group members, the prospect of receiving deduction tokens differs according to the ID letter. The following illustration clarifies the interaction structure at the second decisions stage. An outgoing arrowhead means that you can assign up to 2 deduction tokens to the receiving group member. An incoming arrowhead means that you can be assigned up to 2 deduction tokens by the group member from whom the arrow originates.

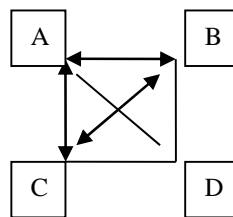


Figure1. Illustration of the interaction structure in the second stage

For instance, consider person A in Figure 1. An outgoing arrow from A to B means that person A can assign up to 2 deduction tokens to person B. An incoming arrow from C to A means that person A can be assigned up to 2 deduction tokens by person C.