Cooperation, Common pool resources and incentives at the sub-group level

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Abstract

The (experimental) research on community management of natural resources focuses on social dilemma situations between individuals. However, in most real-life situations natural resources are not only shared between individuals living in a community, but also between individuals belonging to different subgroups within the same community. For instance, in the case of tropical fisheries, marine resource management typically involves balancing the needs of members from different villages who form the overall community as well as different types of resource users within the same community. Standard Common-pool resource (CPR) experiment does not capture the dynamics of these situations, as they focus only on individual motivations. We introduce four different variations to standard CPR experiment, where we manipulate the incentives at the subgroup level. These four variations include: (i) standard CPR experiment with sub-groups, (ii) CPR experiments where between subgroup competition is conducive to group level cooperation, (iii) CPR experiments where different sub-groups have different incentives to maintain group-level cooperation, and lastly (iv) nested CPR experiments where sub-group incentives are orthogonal to group-level cooperation.

Preliminary findings suggest that, as expected, individuals extract lower amounts from the CPR when individual and sub-group incentives favor cooperation at the group level. Conversely, participants extract significantly higher amount in the case of nested Common-pool resources. Indeed, cooperation is hardest to maintain at both the subgroup and the group level in this case.

Key words: cooperation; natural resource management; group identity; group incentives

Introduction

Hardin´s (1968) classic essay on free-riding problems in the context of natural resources, which he memorably phrased as "tragedy of the commons", had a huge impact on how policy makers and researchers view the problem of sustainable resource management. Hardin´s main argument was that the participants in a commons pool resource (CPR) situation are trapped in an almost inescapable process which inevitably leads to the overexploitation of the resource. The basic assumption behind this argument is that individuals and groups are not able to cooperate even though cooperation is in their mutual interest. This is based on Mancur Olson´s work on the logic of collective action. Olson (2009) challenged the earlier idea that the possibility of group benefits is enough for individuals to cooperate and come to a socially beneficial outcome. According to Olson, "*unless the number of individuals is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interest.*"

This naturally leads to the argument that the only way to overcome these problems is to rely on either government management or to assign private property rights. In the recent past there has been a major push towards government management of natural resources with a particular focus on stringent rules on how and how much resources can be extracted. This means devoting resources and energies in maintaining stringent monitoring and punishment mechanisms/regimes to enforce the rules and regulations. This point of view is based on the assumption that natural common-pool resources are relatively homogenous and the dynamics behind managing these resources relatively simple enough that broad rules and regulations could be drawn which apply to large diverse areas. In other cases where governments felt that these steps were impractical or prohibitively costly, there have been attempts to privatize or to assign some form of private property rights in order to ensure that individuals higher motivation to conserve resources.

However, both these solutions have produced mixed results. Indeed, there have been questions raised as to whether these are the only two possible policy solutions. Ostrom et al. (1994) challenged this strict dichotomy of private property (or market based) solutions and centralized government solutions, by suggesting that communities which rely on the resource are, in some cases, best suited to determine the most sustainable solutions. This critique is based on two broad areas of research. First, detailed case studies in different parts of the world and under different types of natural resource use scenarios have found that "*local groups of resource users, sometimes by themselves and sometimes with the assistance of external authorities, have created a wide diversity of institutional arrangements for coping with common-pool resources*" (Ostrom, 1990).

Secondly, lab experiments show that some of the basic assumptions underlying the "tragedy of the commons" model are flawed. Human-beings have a much greater ability to cooperate even with strangers than assumed by these models. For instance, both lab and field experiments using Common-pool resource (CPR) experiment, have shown that while in completely anonymous setting cooperation is hard to maintain, however even small adjustments such as the possibility to communicate with others and/or punish free-riders can lead to significant gains in sustaining socially beneficial cooperation (Janssen and Anderies, 2011; Ostrom and Walker, 1991; Ostrom et al., 1992).

Overall, the experimental research on community management of natural resources focuses on social dilemma situations between individuals. However, in most real-life situations natural resources are not only shared between individuals living in a community, but also between individuals belonging to different subgroups within the same community. For instance, in the case of tropical fisheries, marine resource management typically involves balancing the needs of members from different villages who form the overall community as well as different types of resource users within the same community.

Standard common-pool resource experiment does not capture the dynamics of these situations, as it focuses only on individual motivations. Recent developments have shown that individuals are more likely to exhibit what is termed as "parochial cooperation" or "in-group favoritism" which suggests that cooperation is more likely when individuals are paired with members of their in-group (De Dreu et al., 2014). Indeed some authors argue that this form of "parochial cooperation" is the most basic form of human cooperation. Furthermore, group identity theory suggests that groups form an identity based on some shared characteristics and are able to manage the collective action problems within this paradigm of shared identity (Tajfel, 2010).

In order to account for these group motivation related issues, we introduce four different variations to standard CPR experiment, where we manipulate the incentives at the sub-group level. These four variations include: (i) standard common-pool resource (CPR) experiment with sub-groups, (ii) CPR experiments where between subgroup competition is conducive to group level cooperation (*intra-group competition treatment*), (iii) CPR experiments where different sub-groups have different incentives to maintain group-level cooperation (*asymmetric conservation benefits treatment*), and lastly (iv) nested social dilemma experiments where sub-group incentive is divergent to group-level cooperation (*nested CPR treatment*).

Preliminary findings suggest that, as expected, individuals extract lower amounts from the CPR when individual and sub-group incentives favor cooperation at the group level. Conversely, participants extract significantly higher amount in the case of nested Common-pool resources. Indeed, cooperation is hardest to maintain at both the sub-group and the group level in this case.

Research design

CPR experiment design

The experiment is framed as an extraction activity from a common fishery. Participants take part in the experiments in groups (G) composed of 6 people. Each group is further divided in two sub-groups (sG_1 & sG_2), with each sub-group having equal number of participants.

Individuals simultaneously and privately decided on how many tokens to extract from the common resource.

Player earnings are given as:

$$\pi_i = (X_i) + Y \qquad (3.1)$$

$$Y = \left(R - \sum_{i=1}^{n} x_i\right)/n$$

X_i are the earnings from resource extraction which is a function of individual extraction level (x_i), Y are the earnings from conservation, R is the amount of the common resource, and *n* is the number of individuals sharing the resource.

The main objective of the experiment is to understand how participants cooperate in natural resource use settings when they are further sub-divided into sub-groups. We are interested in the following scenarios:

Game 1: Standard CPR experiment with sub-groups (control treatment)

In this variation, we only change the framing of the group membership in the standard CPR experiment. We tell participants that the resource is shared between two sub-groups (sG_1 & sG_2), and that the amount extracted by both of them collectively determines how much resource is left behind. Participants belong to sub-groups however their earnings are based on overall group performance. The amount of resource left behind is divided equally between the subgroups and also with-in the sub-group. So, in effect, in a given round the earnings from resource conservation (Y) are the same for each individual in a group.

The optimal strategy for an individual is to extract the maximum possible, similarly at the sub-group level the incentive is to extract the maximum possible resource. However, at the group level social welfare is maximized if no one in the group extracted.

The main objective of this game is to establish a benchmark case where the subgroup design is just a framing issue and has no impact on the player earnings.

Highlights

- The amount of resource not extracted is shared 50-50 between the sub-groups. In pay-off terms this is same as having a 6-person CPR experiment.
- [Individual interests] vs. [Group interests]

Game 2: Intragroup competition and group cooperation

In this variation we allow between-subgroup competition. We tell participants that they are part of a sub-group within the group. Furthermore an individual’s conservation earnings depends on the performance of her sub-group relative to the other subgroup. The main criteria for comparing subgroup performance is the level of cooperation. The subgroup which cooperates the most (extracts the least amount of resource) gets a much larger share of conservation earnings (Y) (75-25 sharing rule). As a result this intra-group competition could be viewed as beneficial for within-group cooperation.

The main objective of this variation is to look at individual and sub-group behavior when the incentive to cooperate are reinforced at the sub-group level. However, since sub-groups are involved in zero-sum competition, so there is a possibility that whatever cooperation happens in earlier rounds can dissipate in subsequent rounds. This is especially true in cases where members of one subgroup believe that other subgroup is able to achieve within sub-group cooperation more readily, and hence the individual increase her extraction to compensate for the expected loss in the conservation earnings as a result of losing the intra-group competition.

Highlights

- The amount of resource not extracted is shared 75-25 where the larger share goes to the sub-group with the lower extraction level.
- ([Individual interests] vs [sub-group interests]) & ([Individual interests] vs [Group interests])
- The optimal strategy for each individual is to extract the maximum possible amount which still allows her sub-group to have lower extraction than the other sub-group.

Game 3: Asymmetrical conservation benefits between sub-groups

In this treatment we allow variation in sub-group incentives for cooperation. The main objective of this variation is to look at individual and sub-group behavior when the incentives to cooperate are asymmetrical for different sub-groups within a group. Within the context of our experimental design, this means that one randomly chosen subgroup gets a much larger share of conservation earnings (75-25 share) than the other sub-group. We expect that the sub-group in advantageous position, receiving 75% of the conservation earnings, is more likely to cooperate and extract lower amount as compared to the disadvantageous sub-group. This lower extraction by advantageous sub-group may also signal the other sub-group to cooperate as well. However given that there are no formal or informal sanctions involved, therefore it is unlikely that advantageous sub-group are able to coerce the disadvantageous sub-group.

Highlights

- The amount of resource not extracted is shared 75-25 where one sub-group gets a larger share (75%) as compared to the other sub-group, irrespective of their actions.
- asymmetrical benefits of conservations
- [Individual interests] vs [Group interests]

Game 4: Nested social dilemma

In this variation we allow the possibility of two different types of resource; (i) Local resource (Rs_1 & Rs_2) shared between sub-group members only, and a (ii) Global resource (R_G) which could be used by anyone in the two sub-groups. The global resource is bigger than any one of the local resource, however has the same value as the combine value of the two local resources.

The main objective of this variation is to look at individual and sub-group behavior when the incentives of individuals and sub-groups do not go in the same direction. For each subgroup the optimal strategy is to extract from the global resource only and conserve the local resource. At the individual level the optimal strategy depends on the expected resource extraction by others from the local as well as the global resource. If the individual believe others are going to extract significant amount of global resource than it is in her best interest to extract from both the global as well as local resource. If, however, agent believes that others are not going to extract significant amounts from the global resource, then it is in her self-interest to focus her extraction on the global resource.

Highlights

- Two resources: CPR_G & $CPR_{S;}$ CPR_G is shared between the sub-groups; CPR_{S1} & CPR_{S2} are shared within sub-groups 1 & 2 respectively.
- From the individual perspective, the optimal strategy depends on the expectation regarding other sub-group as well as other group members.
- From the point of view of a sub-groups, optimal outcome is that all members of the sub-group extract from the group resource (CPR_G).
- From the point of view of the group, the optimal strategy is that no one extracts from any of the resource

Experimental design and session

These experiments were conducted with fishermen and other marine resource users in Zanzibar, Tanzania. Table 1 describes the experimental design in detail.

Table 1: Experimental Design

	Game 1: *CPR experiment with sub-groups*	Game 2: *Intra-group competition treatment*	Game 3: *Asymmetric benefits treatment*	Game 4: *Nested CPR treatment*
	5 rounds	5 rounds	5 rounds	5 rounds
Number of groups	30	30	30	30
Number of sub-groups	60	60	60	60
Number of individuals	180	180	180	180

As shown in table 1, we conducted these experiments with 720 individuals who were divided in 120 different groups. Each treatment had 5 rounds. After each round, participants were given information about the previous round. This information included the amount of resource extracted by their sub-group as well as the other sub-group, whether their sub-group "won" the round (by extracting lower than the other sub-group) (intra-group competition treatment), and both the amount of local as well as global resource extracted by their own sub-group and the group as a whole, respectively (nested CPR treatment).

Additionally, before the start of each round, we elicited participant's beliefs about the performance of their sub-group and group performance. This belief elicitation was incentivized separately so participants had the opportunity to earn extra money by correctly guessing what others were going to do. At the end of each experiment session, participants took part in a detailed questionnaire.

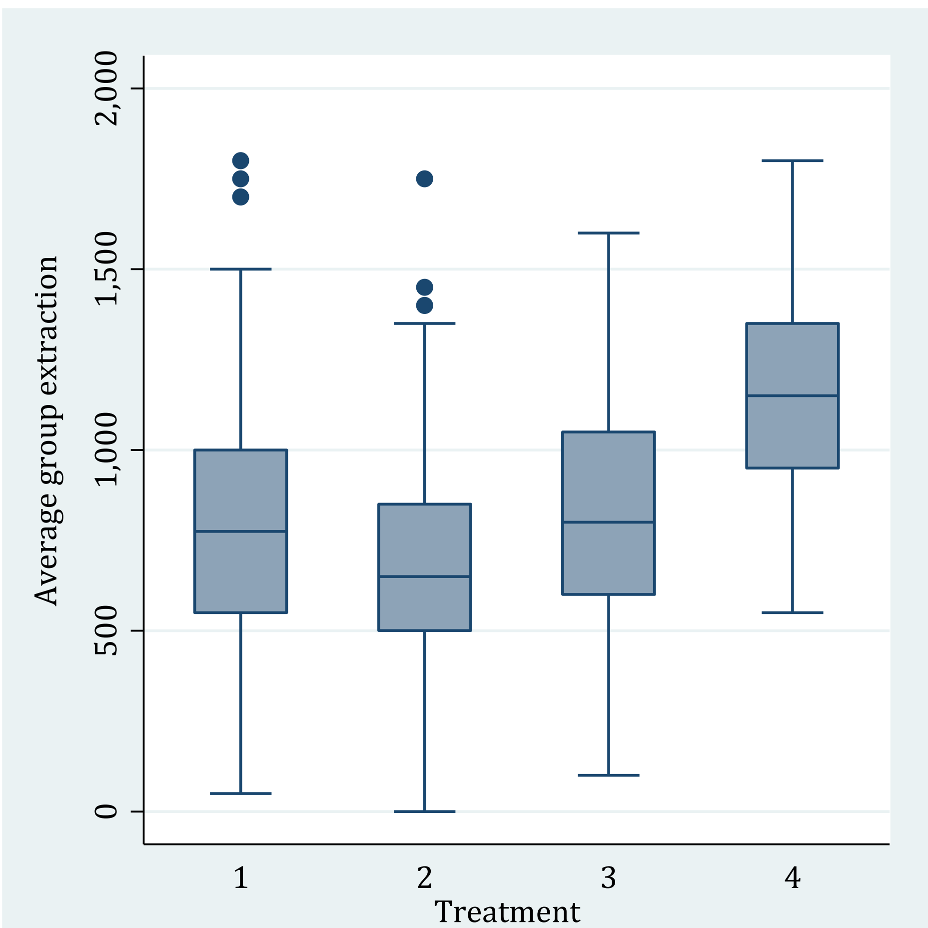
Results

Result 1: comparison across treatments

In order to compare the different sub-group dynamics, we examine the overall extraction level at the group level. This allows us to look at the impact of different treatments on group's cooperation level where cooperation is defined by having as low an extraction level as possible.

Figure 1 shows average extraction level under different treatments. Remember we treat groups under standard CPR with sub-groups treatment as our control group.

Figure 1: Average group extraction level for different Treatments

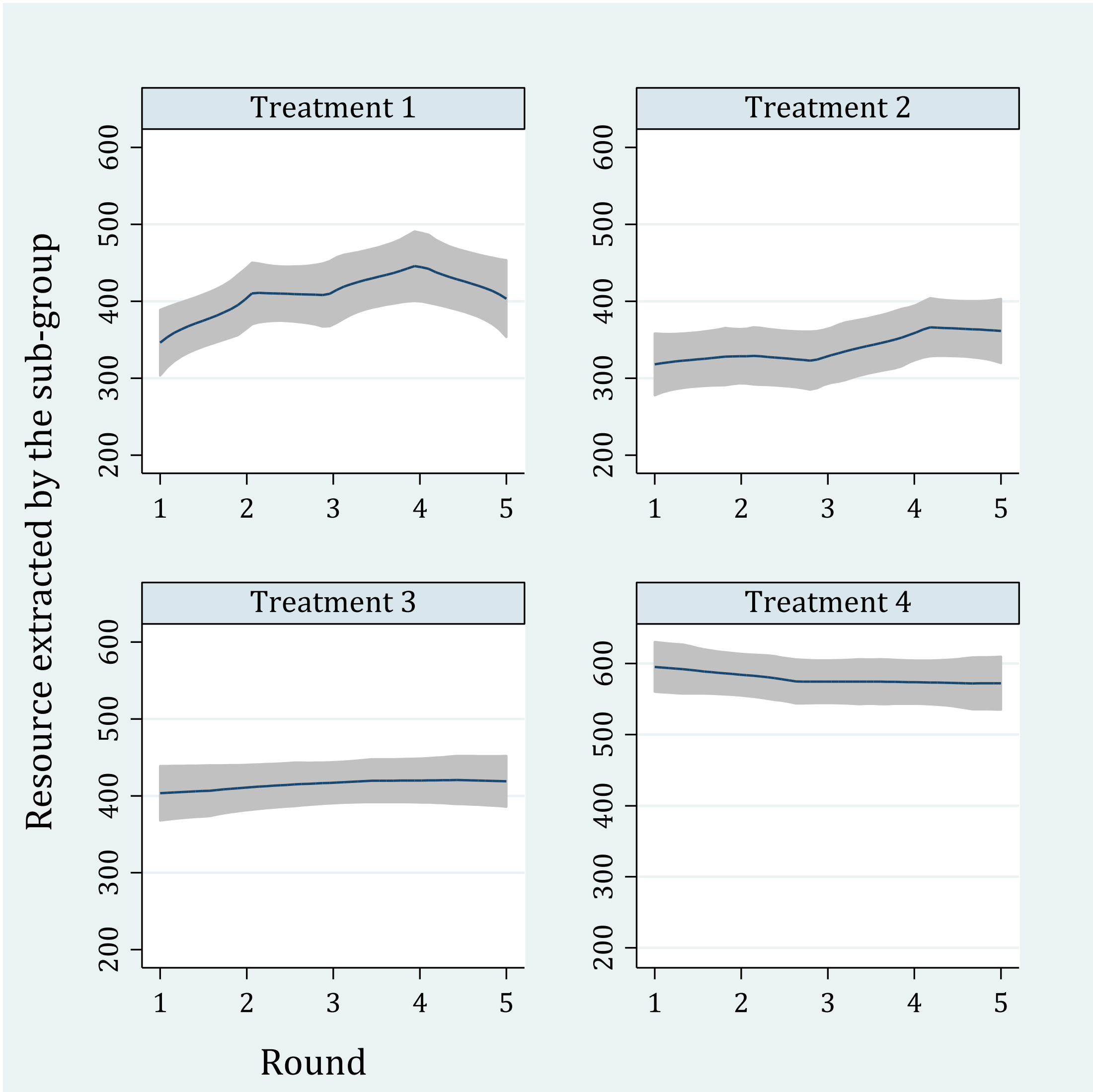


Note: 1 = control treatment; 2 = intra-group competition treatment; 3 = asymmetric benefits treatment; 4 = Nested CPR treatment

Overall we find that average resource extraction for control groups is 803 (±336) tokens which is 40% of the maximum possible extraction level. Comparing it to other treatments we find that, as expected, overall extraction level is lower in inter-group competition treatment, where average extraction level is 677 (±298) tokens, which is substantially lower than the extraction level under control groups. Wilcoxon sign rank test shows that this difference is statistically significant (p-value < .01). On the other hand, extraction level under asymmetric sharing treatment is 825 (±323) tokens which is very similar to the extraction level for control groups. Indeed, Wilcoxon sign rank shows that difference is not statistically significant (p-value = 0.44). Lastly, figure 1 clearly shows that the extraction level is much higher under nested CPR treatment than under any other treatment. The average extraction level is 1162 tokens which is 58% of the maximum extraction level. Comparing this to extraction level under other treatments, we find that this extraction level is significantly higher than control treatment (p-value < .01).

Next we look at the progression of extraction level under different treatments. Figure 2 looks at the average extraction level across different rounds for each treatment individually. Looking at sub-group extraction level allows us to go deeper into treatment manipulations and provides a baseline for later analysis.

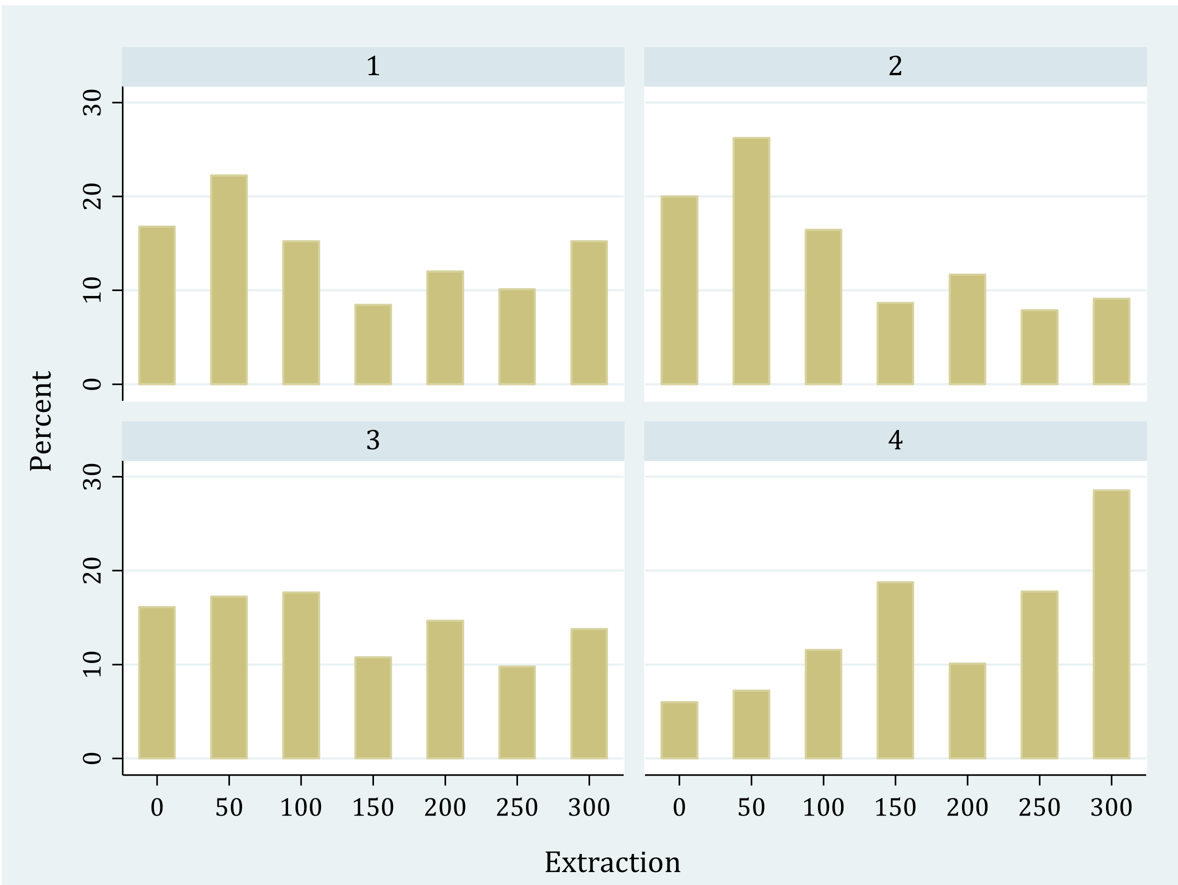
Figure 2: Round by round Average sub-group extraction under different treatments



First, with respect to control treatment we find that extraction level increases over rounds. This finding is in consistent with earlier results from both public good and common-pool resource experiments (Chaudhuri, 2011; Ledyard, 1994). Secondly, with respect to inter-group competition treatment, we observe similar pattern. However the average extraction level is consistently lower than the extraction level in the control groups. This is true for both the first round as well as the last round of the experiment. In contrast, average extraction level remains (more or less) constant in the asymmetric sharing condition. In the first round of the experiment average group extraction is around 400 tokens and stays around there till the last round. Lastly, under nested CPR treatment, average group extraction falls slightly over rounds. However this slight decrease comes from a very high initial level.

Lastly, we look at the frequency of different extraction options at the individual level. Overall, we observe a significant increase in lower extraction options under the inter-group competition. Similarly, we also find a significantly large increase in the maximum extraction options under the nested CPR treatment as compared to control and other treatment groups.

Figure 3: Frequency of individual extraction strategies



So far we have focused on the comparison across different treatments. This meant looking at the overall group extraction level. While this allows comparing different manipulations, it does not provide the opportunity to look deeply at each treatment. In next section we look at the three main treatments separately. We are especially interested in how sub-groups react and learn from the other sub-groups with which they share the resource.

Result 2: inter-group competition treatment

With respect to inter-group competition, we are interested in how sub-groups react to other sub-group. We especially focus on how sub-groups react after losing in one of the rounds. Note that intra-group competition leads to the group with lower extraction benefiting substantially more from the conserved resource (75% of the conserved resource), whereas the group which had relatively higher extraction level receives substantially lower benefits from the conserved resource (25% of the conserved resource).

For the purpose of this paper we refer to the group with relatively lower extraction in a given round as "winner", whereas the group with relatively higher extraction as "loser". Note that this classification was not used during the experiment.

For this treatment we are interested in two different things. First, how do different groups behave in the first round when they know that they are engaged in this intra-group competition? Secondly, we are also interested in how groups react to being winner or loser in the subsequent rounds. Given the experiment design we can expect three different reactions:

Scenario 1: Loser sub-groups lower their extraction in order to increase their chances of winning the subsequent rounds. This competition eventually leads to a situation where both groups operate on their minimum possible resource extraction level.

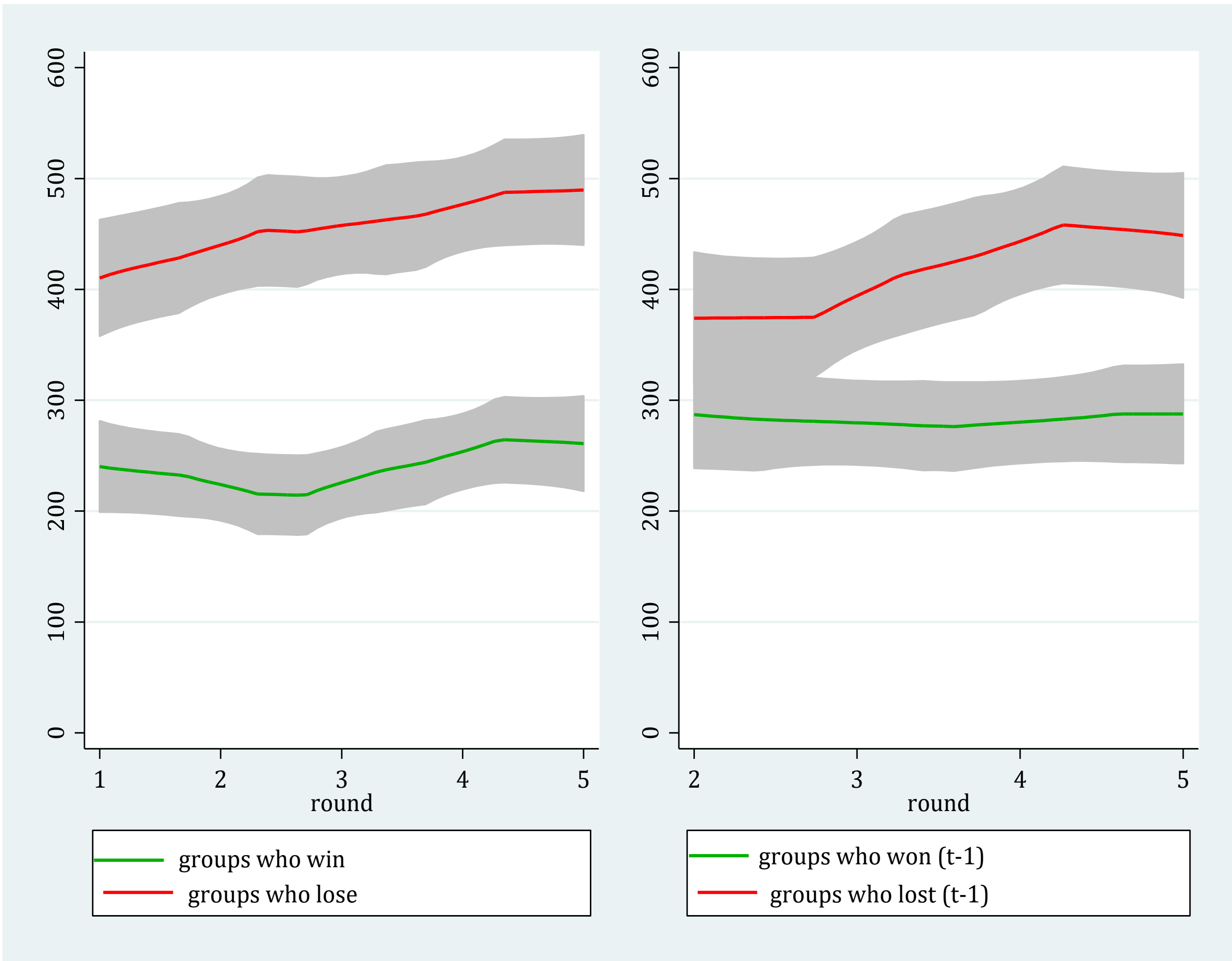
Scenario 2: Loser sub-groups increase their extraction as they do not expect to go lower than the extraction level of the winner groups.

Scenario 3: Sub-groups do not respond to behavior of other sub-group and make their decision independent of what they think other sub-group is going to do.

Below we attempt to understand sub-group in the context of these different strategies.

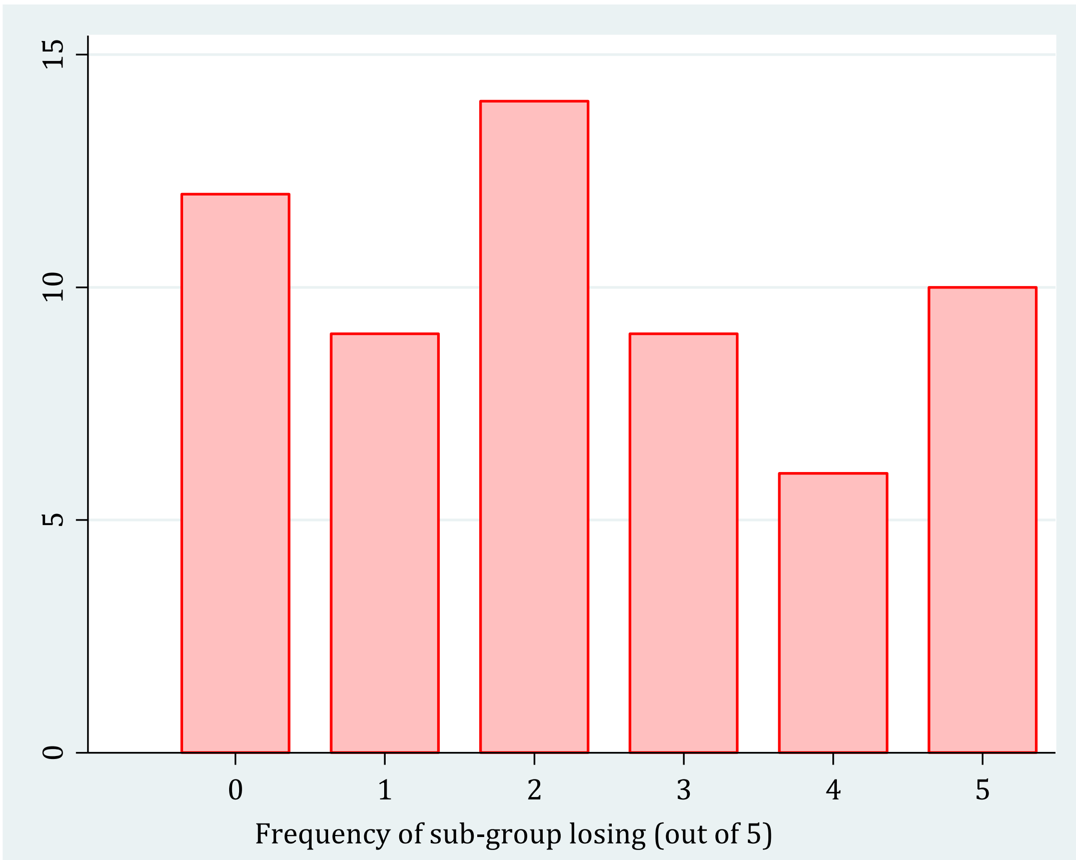
Figure 2(a) present the average extraction in different round for both winner & loser sub-groups. We are interested in whether the difference between winning and losing sub-groups change over time. Figure 2 (b) presents the average extraction level for sub-groups who won in the preceding round as compared to those who lost in the preceding round. This allows us to look at the reaction of sub-groups to winning or losing in the previous round.

Figure 4: average sub-group extraction for sub-groups who "win" and sub-groups who "lose"



First, we notice that the difference between winning and losing extraction level increases over time. We also notice that this increase is mainly a result of increased losing extraction level, whereas the winning extraction level remains more or less the same. Secondly, looking at figure 2 (b) suggests that the reaction to losing in the previous round changes over time. In the initial rounds, sub-groups who lost in the previous rounds, extract on average higher than the sub-groups who won in the previous round. However this difference is relatively small. Meanwhile, in the latter rounds this difference increases substantially.

Figure 5: Frequency of sub-groups losing the intra-group competition (out of 5 rounds)



Lastly, we look at the frequency of sub-groups losing the intra-group competition over the course of 5 rounds. We find that 37% of the sub-groups either never lose or always lose. Furthermore, additional 25% of the subgroups have a dominant strategy in the sense that they either win or lose in at least 4 out of 5 rounds. Overall, we can say that 62% of the sub-groups are able to maintain their status as a winner or loser in majority of the rounds. Whereas, in 38% groups the winner & loser sub-group changes often.

Overall, looking at all the evidence in conjecture, we believe that groups in our intra-group competition treatment follow the scenario 2. We do not find any strong evidence that intra-group competition leads to decreasing extraction over time. Rather, we find that some sub-groups are able to cooperate more readily while others not. Intra-group competition condition basically lead these sub-groups to sort themselves in their respective roles, where sub-groups which are able to cooperate readily, decrease their extraction level and are therefore able to enjoy larger share of conservation earnings in most cases. Similarly, sub-groups which do not expect to win the intra-group competition consistently extract at a much higher level than winning sub-group, and therefore rely on their extraction earnings rather than trying to obtain higher share of conservation earnings.

Result 3: asymmetric treatment

With respect to this treatment we are interested in two main issues: 1) how do sub-groups which were randomly assigned to advantageous or disadvantageous position react to this assignment, 2) how do sub-group behavior change over time, more specifically whether there is a difference in change in behavior over time based on the assigned roles.

Figure 6: Average sub-group extraction by disadvantaged and advantaged sub-groups

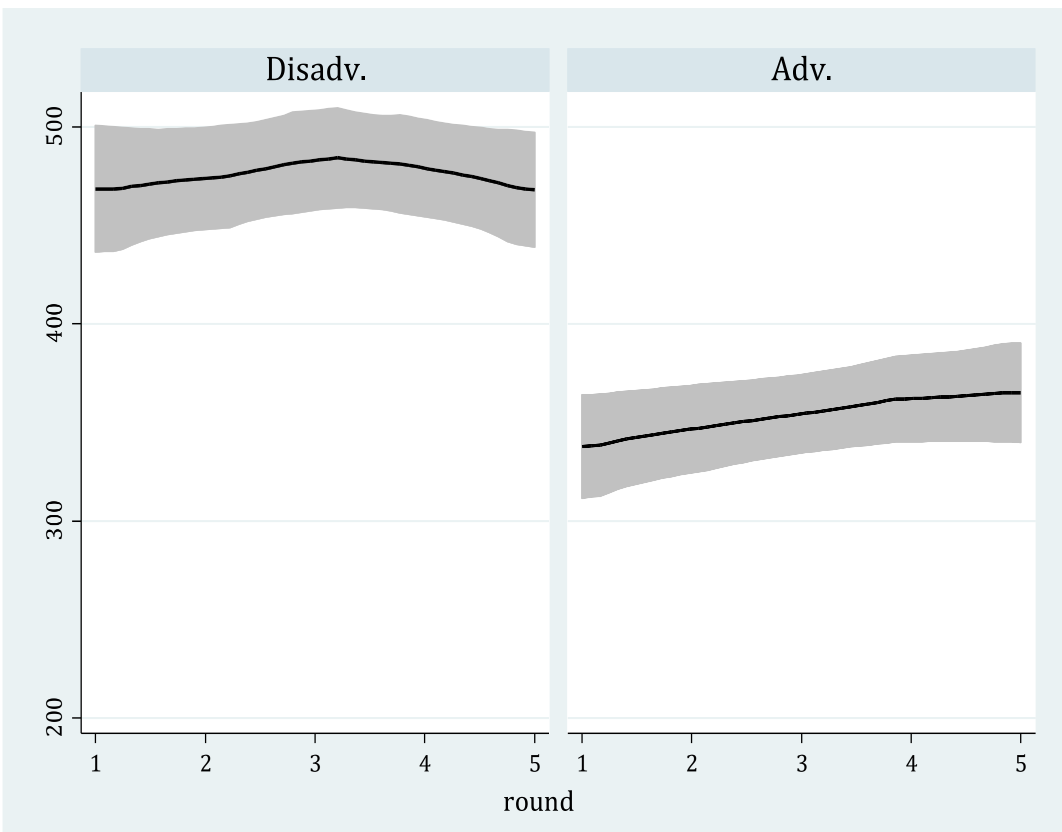


Figure 6 shows average extraction for sub-groups over time for both disadvantaged and advantaged groups. First we observe that sub-groups which are in disadvantaged position extract more than those who are in advantageous position. Looking at sub-group extraction by round, we find that this difference between disadvantaged and advantaged sub-groups is statistically significant for all 5 rounds.

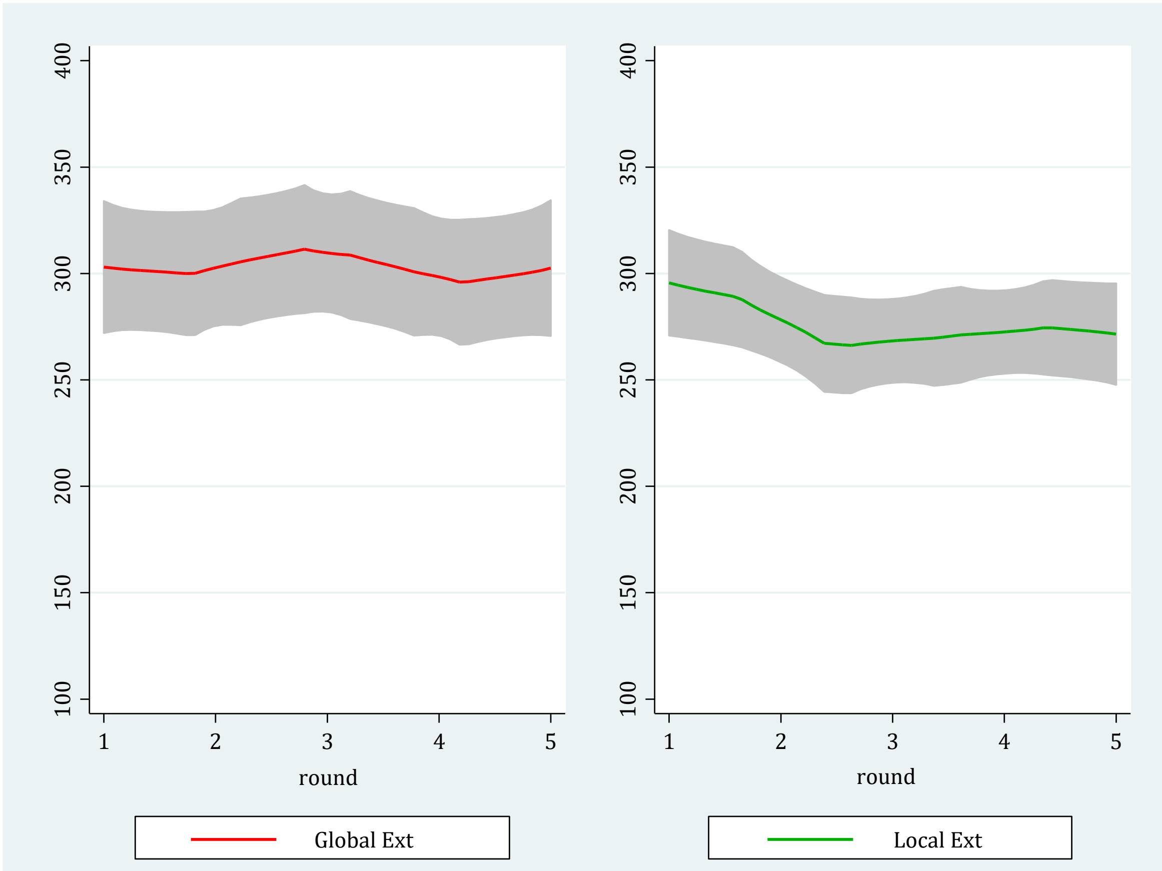
The extraction level for disadvantaged groups remain more or less similar for all 5 rounds, whereas there is slight increase in the extraction level of the advantaged groups. However, looking more closely, we find that the change in extraction level in rounds between advantaged & disadvantaged sub-groups is quite similar and statistically not significant. Overall, we find that for most of the groups, the disadvantaged sub-group extracts more than advantaged group, and that this difference is present from the start of the experiment. More specifically, we observe that in only 4 out of 30 groups the advantaged group consistently extract more than the disadvantaged sub-group. Furthermore, around 35% of the advantaged & disadvantaged sub-groups increase their extraction level over time, whereas a similar number decrease their extraction level over time. However, the number of instances where both advantaged and disadvantaged sub-groups move in the same direction is rather limited.

Result 4: Nested CPR

In this section, we look at level of extraction in nested CPR treatment, we are especially interested in how participants decide between extraction from local and global resource.

Figure 7 presents the average Global and Local sub-group extraction level for the whole experiment (5 rounds).

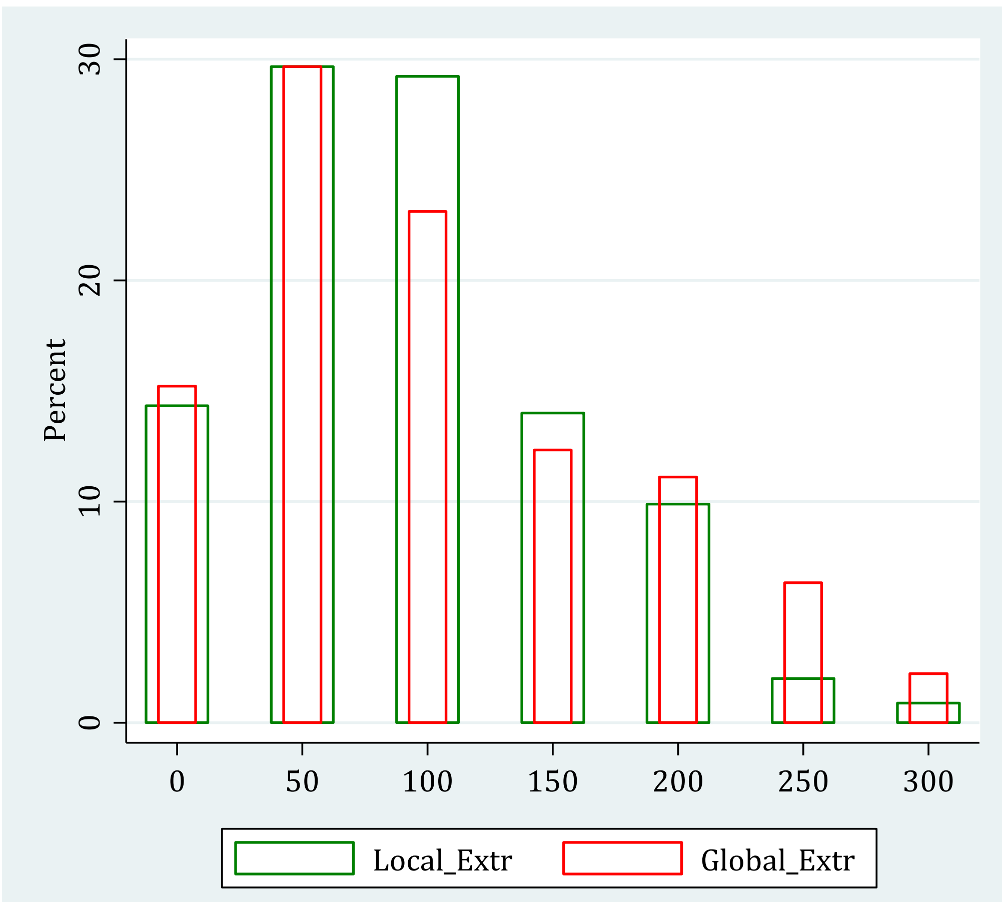
Figure 7: average sub-group extraction from local as well as global resource



We notice that the resource extracted from both Global and Local resource is quite similar in first round. The amount of resource extracted from Local resource decreases slightly in the latter rounds, whereas the extraction level from Global resource remains more or less the same. However, the difference between extraction from Global and Local resource is statistically significant for only 1 of the 5 rounds at the 5% level (or for 2 rounds at the 10% level). Furthermore, we find that in 40% of the rounds and 46% of the sub-group, the total sub-group extraction from Local resource was higher than the total sub-group extraction from the Global resource. Given the fact that extracting higher share from Global resource is more desirable from the sub-group perspective as well as individual perspective (only if the overall group extraction level is low), it is surprising to observe that the difference between Global and Local resource extraction is not very high.

Looking at the frequency of different extraction options for both Local and Global resource, again we find very similar individual extraction strategies. Overall, the main difference lies in the number of times maximum or near maximum extraction level was taken from Global resource as compared to the Local resource. The number of time individuals extract the maximum possible amount from the Global resource is significantly higher than the number of times this strategy was employed for the local resource. However, it should be noted that even for Global resource the strategy to extract maximum possible amount from the Global resource only, is employed in only a small number of cases (around 5% of all cases).

Figure 8: Frequency of Individual extraction strategy from local and global resource



Concluding remarks

We conducted CPR experiments with four different treatments to study how group dynamics interact with individual´s decision-making in common-pool resource management scenario. These treatments were introduced to manipulate the incentives to cooperate at the sub-group level. Our findings indicate that groups find it extremely difficult to cooperate in a nested social dilemma situation where individual, sub-group and group interests differ from each other. Under this treatment the extraction level is almost 50% higher than the extraction during control treatment. We also find that inter-group competition treatment leads to lower extraction level than the control treatment and that this difference remain for all 5 rounds of the experiment. Furthermore, we do not find any significant difference between extractions under asymmetric benefits treatment as compared to control treatment.

These findings indicate that when individuals have conflicted motivations between individual, sub-group and group interests, the possibility of cooperation becomes lower. Even more interestingly, we find that in nested CPR situations, sub-groups on average extract equally from both local and global resources. This is particularly interesting because it is in sub-group´s self-interest to not extract from the local resource and focus only on the global resource. This shows that at least in the context of nested natural resource management, individual´s self-interest over-rides both sub-group and group interest. On the other hand, we find that sub-groups can have a more influential role when the possibility of intra-group competition favors cooperative outcomes. However, it is not clear whether providing these incentives at the individual level rather than the sub-group level could have also led to similar results.

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