Real Wealth and Experimental Cooperation: Evidence from Field Experiments

Juan-Camilo Cardenas[1]
Visiting Scholar, Indiana University (jcardena@indiana.edu)
Facultad de Estudios Ambientales y Rurales, Universidad Javeriana, Colombia
(jccarden@javercol.javeriana.edu.co)
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Abstract:

This paper is about the role of poverty and inequality on communities trying to solve local commons dilemmas. The debate remains alive since Olson's (1965) argument that the privileged in a group facing a collective action problem may facilitate the provision of the public good despite the free riding of the poorer. Olson's hypothesis, however, has been contested by some arguing that inequality can create efficiency losses due to asymmetries of information, power or wealth , among others, which reduce the capacity of groups to achieve Pareto optimal equilibria. Experimental economics can and has been used to test with college students for these contrasting arguments. We expand the evidence by conducting a series of experiments in the field where the subjects are actual local commons users. We use additional information about the participants' real world features and test if such factors affected their behavior in the lab in a simple Common-Pool Resources experiment with groups of 8 people. We found that factors such as actual wealth and occupation as well as group composition explain the rather wide variability on the level of cooperation achieved after allowing face-to-face communication before each round, for a sample of 10 groups. We first tested these hypotheses at group level finding that wealth and heterogeneity may be negatively associated with cooperation and efficiency. Then at a micro level we test and show that the individual is more willing to cooperate through face-to-face communication if i) has a lower level of real wealth, ii) her occupation is associated with local commons dilemmas, iii) and is playing in a group where she shows lower social distance with respect to the other 7 players. The results could be relevant not only for the inequality-cooperation debate, but for the debate on the power of experimental economics to tackle these type of questions.

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Do poverty and inequality affect the capabilities of communities to overcome the *tragedy of the commons*? Could societies rely upon the rural poor to manage sustainably local commons that may provide benefits to others, even outside the community? The incentives to overuse common-pool resources are well understood, and a variety of market and state based solutions have been advanced and put into effect with various levels of success. But there is also evidence that in some circumstances, in fact, members of a community may voluntarily cooperate to produce a socially superior outcome, despite the incentives associated with the so called tragedy (Ostrom, 1990; Ostrom et.al. 1994; Berkes, 1989). This paper studies how wealth and other factors of group composition may affect the likelihood of cooperation and self-governance in a local commons dilemma by using evidence from field experiments.

1. Introduction.

How wealth and inequality play a role on the level of cooperation in collective action dilemmas remains a crucial but open question in the literature. Olson (1965) suggested that the existence of privileged members in a group could increase the level of voluntary provision of the public good in collective action dilemmas. Bergstrom, Blume and Varian (1986), for the case of pure public goods, have also proposed that income would increase such voluntary contributions while those with lower income would free-ride on the provision by the rich. In contrast, others have argued against such claims by studying the losses in efficiency that arise from social exchange in unequal or heterogenous groups. New empirical and theoretical works suggest that unequal distributions of wealth or heterogeneity within group members can reduce their capacity to coordinate their actions towards Pareto superior outcomes. One of the arguments is that heterogeneity, wealth inequality and social distance in a group can hinder key motors of cooperation such as reciprocity and trust in the solution of these dilemmas (Bardhan, 1993, 1999; Dayton-Johnson, 1999; Alesina and Le Ferrara, 1999; Bardhan, Bowles and Gintis, 1998; Ostrom, 1998, Varughese and Ostrom, 1999).

A plausible approach for testing such propositions is through economic experiments where one can study how changes in certain institutions affect group outcomes as well as being able to observe individual behavior. In fact some attempts have been made by experimentalists to study the effects on cooperation of different types of heterogeneity and social distance contexts. Hoffmann, McCabe and Smith (1999, 1996); Kramer and Brewer (1984); Chan et.al (1996), Lawler and Yoon (1996) and Hackett, Schlager and Walker (1994) have shown through different types of experiments how group heterogeneity affects in various ways cooperation sometimes in contradiction with the Olsonian proposition.

Loomes (1999) and Lowenstein (1999) raise however some interesting questions about the limits of experiments based on observing behavior of college students who might not necessarily be influenced in the same way the actual decision makers are on the particular question of inquiry.

This paper attempts to respond to some of these questions by studying cooperation within groups facing local commons dilemmas[2] and by applying economic experiments in actual rural villages where the subjects are real world users of local commons, members of the same community. Further, we will use information on the actual levels of heterogeneity in terms of wealth, occupation

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[2] Technically our problem and model is not different from a negative group externality case, and it may differ from some definitions of "common property" in certain technical details, for instance on whether the productivity of members of the group is affected by the effort of one member. We do not intend to model a pure "common property" case but a local commons situation where there is a private property or activity component for each member, and partially open access to a resource. In the pure common property case, the models assume that all income is derived from the commons which is under collective property, while the proposed model here wants to reflect a commonplace situation frequent in many regions where households allocate their effort between private production and the extraction of a resource accessible for all.

and others, to observe their effects in experimental behavior. Through these field experiments we have been able to replicate some of the existing experimental evidence on cooperation in groups but also expanded the evidence by learning more about the real-world set of preferences and institutional constraints people are subject to, and how these may affect the outcome in the field laboratory. We believe that we can explain part of the variability usually found in these types of experiments by accounting for some of the real characteristics of the subjects.

In particular, we will present evidence that the actual levels and composition of actual wealth as well as the real world occupation of the participants play a role in the level of cooperation and the solution of the local commons dilemma they faced through the experiment sessions. At the group level, we found that group efficiency improved for nearly all groups when introducing face-to-face communication, quite consistent with most experimental evidence in public goods and CPR experiments. However, and also consistent with previous experiments (OGW, 1994), the gains in efficiency varied greatly across groups despite having played the same treatment design and payoffs incentives. The data collected on their real-world institutions and behavior help explain part of this variability. The most striking and significant result is that the composition of the real wealth level and distribution within each of the groups affected directly the experimental outcome. In brief, at the group level average wealth decreased the level of cooperation and therefore reduced social efficiency achieved by the group, and secondly, variance in the distribution of real wealth within the group also decreased social efficiency.

Likely explanations for such results is that wealth determines many elements of individuals' decisions about local commons dilemmas and also affects how communities solve the conflicts arising from them. On the one hand poorer people show a higher probability of interaction with neighbors which has been argued to increase relations of reciprocity and trust. For the poor a higher number of activities are based on more horizontal social exchange relations such as reciprocal labor exchanges, equipment sharing, informal credit, and community projects. An even simpler argument could be that the smaller your farm the more frequent -and easier- you see and need your neighbor. On the other, less wealthy people have a higher dependence on common-pool resources such as irrigation, forests and similar community resources, and therefore are more familiar in acting under such dilemmas, while wealthier people have their production function mostly based on privately owned inputs.

On the other hand we found that the effectiveness of communication among more heterogenous subjects is reduced. One possibility is that there might be less trust and it is more difficulty to find optimal solutions to the game when there is greater distance created by wealth differences within the group.

Do people bring this information into the field lab, and do they use it for their decision? We believe so and provide statistical support. We tested these arguments above at group and individual level by modeling the individual's decision in each round using regression analysis. The estimations attempt to explain the variability of cooperation as a function of i) the incentives created by the experimental design and the specific situation in each round, ii) the incentives to cooperate created by a repeated game, iii) the individual's real characteristics, and iv) the characteristics of the group -or context- in which the individual participated. The estimations confirm the arguments that own's wealth and the difference in wealth with respect to the rest of the group reduces the individual's willingness to cooperate in solving the collective action.

2. A local commons setting for a field experiment design.

The experimental setting we designed is quite similar to the actual incentives the participants face in their daily life where households benefits from multiple products from a patch of forest or mangrove which may be part of a national park but where access is rather easy for any neighbor in the village, given the low enforcement of the exclusion and use rules by the government. The benefits from this forest are increasing on one's extraction of products, but decreasing on the aggregate extraction due to reduction on public goods benefits from the forest such as water supply or biodiversity. Therefore, the definition of local commons dilemma that is being used in this paper and in the model to follow below, is one that shares the problem of non excludability with public goods and the problem of subtractability with private goods as Ostrom (1990) describes common-pool resources dilemmas.

So far we are assuming a homogenous group of individuals where the pecuniary incentives they face are symmetrical. But homogeneity in groups is not generalized. Most villages present in reality a variety of types of heterogeneity regarding, for instance, the marginal net benefits of using the commons by each individual. Some may have better equipment to extract the resource reducing their effort cost more than for others. Those with better exit options such as better land or better education might gain comparatively less from extracting it, while other might derive most of their income from it. The better off can play a positive role in providing the public good because they might have a higher gain from the collective action of controlling overextraction. The debate was formally started with Olson's (1965) proposition of the privileged group, and has since advanced through modeling, field and experimental work[3]. However, recent theoretical arguments are also

[3] See Varughese and Ostrom (1999) for a recent review of the wide range of factors that may be involved in the relation between heterogeneity and the solutions to commons dilemmas.

suggesting that cooperation in local commons dilemmas may decrease with inequality (Baland and Platteau, 1997b; Bardhan, Bowles and Gintis, 1998; Dayton-Johnson and Bardhan, 1996; De Janvry, McCarthy and Sadoulet). Most of these focus on asymmetric payoff functions and how there might be different outcomes on the level of cooperation by wealthier and poorer. In another paper we study through a similar set of field experiments how payoff asymmetries may affect extraction and cooperation (Cardenas, 1999).

But still under a symmetric payoffs setting, heterogeneity of other variables might affect the way a community attempts to solve endogenously the tragedy of the commons. If no external regulation is in effect in controlling excessive extraction by some, and the community tries to design self-governing mechanisms, still the distribution of wealth, power or interests can play a crucial role in the effectiveness of self-governance institutions. Some could argue that the wealthy can provide the economic or political conditions for getting access to government resources necessary for a better management and control of the resource. In many cases they also provide leadership given their better knowledge of regulations, or because of respectability among the group.

On the other hand there are those arguing that inequality may affect negatively the emergence of collective action and cooperation because it increases the social distance among group members and therefore it reduces key elements in cooperation such as trust and reciprocity. For instance, Alesina and La Ferrara (1999) show from a General Social Survey (1974-94) sample from U.S. citizens that the participation in social activities decreases in more unequal and more racially or ethnically heterogenous groups. They also cite La Ferrara (1998) data from Tanzania where *"the degree of participation in groups which provide economic benefits or informal insurance to their members is inversely related to income inequality in the community"*. Another argument for such claim is on the effect that social distance may play in inducing cooperative behavior among individuals despite the predictions from non-cooperative game theory. Hoffman, McCabe and Smith (1999, 1996) showed how increasing the social distance through framing the problem to the subjects in a dictator game reduced the offers. By altering the way the task of dividing the money is presented to the two players they induced different social norms about the social interaction. Such social norms regulate the degree of reciprocity in the decisions. They found that the more impersonal the task for the players, the lower the levels of cooperation. They interpret their results saying that *"...decreasing social distance increases other regarding behavior"* (1999: 340). Further, the experimental evidence presented by Kramer and Brewer (1984) supports the argument that individuals might be prone to cooperate more when there is a greater sense of group identity, which is probably stronger in more homogenous groups where members develop a group identity based on what they are, do or have.

a. The payoff model.

The payoffs for our experiments were generated by a simple model of a fixed number of homogenous individuals that exploit a local forest for firewood. In each round of the games, each individual is given an endowment of time e that can be allocated to collecting firewood or to providing labor to an unrelated market. Let x_i denote the amount of time individual i spends collecting firewood from the common, and let w denote the prevailing wage for labor. Then, i's decision to provide $(e - x_i)$ units of labor to the formal sector yields a payoff of $w \times (e - x_i)$. Time spent collecting firewood from the forest yields a private benefit, which we assume takes the quadratic form $g(x_i) = \gamma x_i - \varphi(x_i)^2 /2$, where γ and φ are strictly positive and are chosen in part to guarantee $g(x_i) > 0$, for $x_i \in [1, e]$. The strict concavity of $g(x_i)$ indicates diminishing marginal private returns to time spent collecting firewood.

Subjects were told explicitly that their decision to spend time extracting firewood would also affect water quality in the area adversely, for instance, because of erosion and sedimentation at the upper watershed. We assumed that water quality q is a quadratic function of the aggregate amount of time individuals in the community spend collecting firewood; specifically, $q(\sum x_j) = q^0 - (\sum x_j)^2/2$, where q^0 is interpreted to be water quality in the absence of firewood extraction. Again these parameters are chosen in part to guarantee $q(\sum x_j) > 0$ for all feasible $\sum x_j$. An individual's valuation of water quality is $f(\sum x_j) = q(\sum x_j)$.

Define $u(x_i, \sum x_j)$ to be the sum of the sources of utility for an individual exploiter of the local forest. Parameters were chosen, in part, to guarantee that $u(x_i, \sum x_j) > 0$ for all possible x_i and $\sum x_j$. To facilitate scaling individual payoffs, we take an individual's payoff function to be a positive, monotonic transformation F of u. In particular, $F(u) = k(u)^\eta$, where k and η are all positive constants. An individual's payoff function is then

$$U_i(x_i, \sum x_j) = k[(q^o - (\sum x_j)^2/2) + (\gamma x_i - \varphi(x_i)^2/2) + w_i \times (e - x_i)]^\eta \qquad [1]$$

Each group consisted of n = 8 subjects, and each subject was allocated e = 8 units of time in each round. Pre-testing of the experimental designs at the University of Massachusetts and at the Humboldt Institute for Biodiversity in Villa de Leyva, Colombia, led us to denominate units of time as months per year. Scale concerns led us to choose the following remaining parameter values: k=(4/16810), η=2, q^o=1372.8, γ=97.2, φ=3.2, w_i=30, and e=8. Individual payoffs were therefore calculated from the payoff function:

$$U_i(x_i, \sum x_j) = (4/16810)\, [(1372.8 - (\sum x_j)^2/2) + (97.2\, x_i - 3.2(x_i)^2/2) + 30 \times (8 - x_i)]^2 \qquad [2]$$

Subjects were given a table of payoffs (Table A.7, excluding the highlighting of some of the cells) as a function of individual choices and the choices of all other participants. In each group all subjects received the same payoff table, and they were notified of this so that this was common knowledge.

Nash Strategies and the Balance Between Self-Interested and Other-Regarding Behavior. Because extracting firewood generates a pure public bad in the form of lower water quality, standard theory predicts that purely self-interested individuals will spend more time harvesting firewood than is socially optimal. Indeed, one common reference point for experiments of this type is the one-shot, complete-information Nash equilibrium (the standard model of purely self-interested strategic behavior) and another is the outcome at which group welfare is maximized. Although we won't ignore these benchmarks, we believe that for an investigation of whether external controls on individual behavior crowd out group-oriented behavior, a more appropriate benchmark are the individuals' pure Nash strategies—that is, individual payoff-maximizing choices taking the choices of the rest of the group as fixed. In fact, we take the difference between an individual's Nash best-response to the choices of the other players in the group and his or her actual choice to be an indicator of how that individual balances self interests and those of the entire group.

To illustrate the point, suppose there are eight players and each of seven players choose to spend two months collecting firewood from the surrounding forest. Since the sum of the seven players' choices is 14 months, Table A.7 indicates that the eighth player's payoff-maximizing response – the individual's Nash best-response – is to spend eight months collecting firewood. [We have highlighted the cells Table A.7 that indicate an individual's pure Nash strategy for each level of "their months in the forest"]. This choice is made purely out of self-interest, without regard for the welfare of the others in the group. Note that his or her payoff in this outcome is 776 points, while each of the other seven receive 535 points [for each of them, the sum of the others' choices is 20 months, while they choose 2 months].

Now imagine that the eighth player chooses 3 months instead of 8, while the other seven players continue to choose 2 months. We consider this to be a significantly more group-oriented choice – it is costly because that player's payoff is now 652 points instead of 776: however, each of the other players' payoffs increase from 535 points to 606 [for each of them, the sum of the others' choices is now 15 months, while they choose 2 months]. Much of our analysis that follows is based upon the differences between the players' actual choices and their Nash best-responses: choices that are close to Nash responses indicate relatively self-interested behavior, while those that are further away indicate stronger other-regarding or cooperative behavior. As for the standard benchmarks, it is straightforward to show that in our design the optimal amount of time each individual should spend collecting firewood is 1 month[4]. On the other hand, since a pure strategy Nash equilibrium requires that every player's choice be a best-response to every other player's best-response, in this context the Nash equilibrium is reached if every individual decides to spend 6 months collecting firewood from the nearby forest. It is worth noting that at the Nash equilibrium, subjects earn only about 24% of the payoffs attainable in the efficient outcome.

The following table summarizes the choice variable and outcomes for the two benchmarks of comparison for our analysis.

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[4] Since the player's payoffs are identical, optimality requires symmetric individual choices. Let x denote the common amount of time each individual spends collecting firewood in any symmetric outcome. Using [1], the joint welfare function is $W(x) = n(k)[(q^0 - (nx)^2/2) + (\gamma x - \varphi(x)^2/2) + w\times(e - x)]^\eta$. The first-order condition for the maximization of W(x) requires $-xn^2 + \gamma - \varphi x - w = 0$. Solving for x and substituting the actual parameter values yields optimal individual amounts of time spent harvesting firewood, $x^* = (\gamma - w)/(\varphi + n^2) = 1$.

Two Benchmarks for equilibria in the commons game		Symmetric game (All 8 players)
Social optimal solution (GroupMax strategy)	**Individual decision (X^{opt})**	$X_S^{opt} = 1$
	Earnings ($) per round per player	Y_S^{opt} = $645
	Group Earnings	$SUMY_S^{opt}$ = $5,160
Nash solution (IndivMax strategy)	**Individual decision (X^{nash})**	$X_S^{nash} = 6$
	Earnings ($) per round per player	Y_S^{nash} = $155
	Group Earnings	$SUMY_S^{nash}$ = $1,240

Table 1. Benchmarks for equilibria in the game.

b. Experimental design, subjects and field setting

The experiment followed most of the convention in CPR experiments (OGW, 1994) in that it involves groups of 8 subjects who participate in a set of rounds where they make their individual decisions $x_i \in [0,8]$, according to the payoff table. The subjects sat at individual desks that were distributed in a circle with enough separation between the desks so they could not look at another's work. Except in periods when communication was allowed, the desks faced away from the center of the circle. In each round, each subject would choose how many units of time, $x_i \in [0,8]$, to spend collecting firewood from a local forest. Subjects were given the payoff table [Table A.7 without the shading] and they knew that the other participants consulted the same table. Thus, although individuals could not know in advance what the others would choose, they knew that their decisions were based on the same payoffs. Once a subject made a decision for a particular round, this decision was written on a slip of paper. When all subjects had made their decisions, a monitor collected each slip of paper and gave them to another monitor who recorded the individual decisions and calculated the total for the group. This total was announced to the subjects, who then determined their own payoffs from the payoff table. Subjects kept a record of their own payoffs as a check on the monitor's record.

Each session began with some welcoming remarks within which the subjects were told that the session would last approximately two hours. A monitor would then read the instructions to the participants. [The instructions are available from the author]. Results from pre-tests of the experiment led us to decide not to give the subjects written instructions because of the wide variation in levels of literacy among the subjects. The instructions explained the basic setting of the game, how points were earned, how these points were converted to cash at the end of the session, and the procedures of the game. The instructions included three different examples to familiarize the subjects with the payoffs and the procedures. Two practice rounds were conducted. The monitor asked for questions at several points, and when there were no further questions the game began with round 1. Large, readable posters of the payoff table, the forms the subjects used during the game, and the examples from the instructions were placed on one wall of the 'field lab'.

For this experiment we recruited 10 groups of 8 participants each. The groups played 8-11 initial rounds of the game, without knowing exactly how many rounds the game would last, and neither what kind of new rules would be played afterwards. During these initial rounds individuals made their choices without communicating with the others or the monitors. After this first stage the monitors would stop the game and announce a new set of rules for the forthcoming rounds. The monitor read a new large poster announcing that from now on the group would be allowed to have a 5 minutes open discussion before the decision for the next round. The discussion should be about anything they wanted on the game but could not include any kind of threats or promises of transfers of points or cash after the game. After the decision in each round, the participants should return to their individual desks and make their individual and still private choice for x_i. The groups played this sequence [discussion -> individual decision] for about 9-12 rounds, and again, the subjects did not know when the last round was going to be.

The participants. In total, 80 subjects from 3 villages participated in the experiments. The invitation was made to all adults who lived in that village. We avoided having close relatives play within the same group. They were told that they were to participate in a set of games from which they could earn some prizes. Two days after the end of the sessions, they were all invited to participate in a community workshop to discuss the results of the games, without revealing the individual gains. All players received a show-up prize (a household item e.g. lamp, table set, machete, etc) of similar prize, and their points earned were converted into cash. The average gain for a player equaled as planned the equivalent of 1.5 days of work at the minimum local wage which was aimed at compensating them for participating in the game and in the workshop two days later. Also, they had to fill out a exit-survey questionnaire after the game with follow-up questions about the game, and household data on their economic activities, participation in social life, and preferences about certain issues related to our study.

The appendix (Tables A.4. and A.5.) show some basic statistics for the demographic and socio-economic characteristics of the participants. All villages, although apart geographically and culturally, represented cases where a small rural community had relatively open access to a local area rich in natural resources from which they extracted firewood, while having sporadic logging, fishing, and hunting. The natural areas in these villages are legally under state or private property, but the enforcement of such rights is very weak due to transaction costs and political conflict which affects all rural areas of Colombia.

3. **Experimental results**.

The results from the 10 groups who participated under this symmetric payoffs treatment are

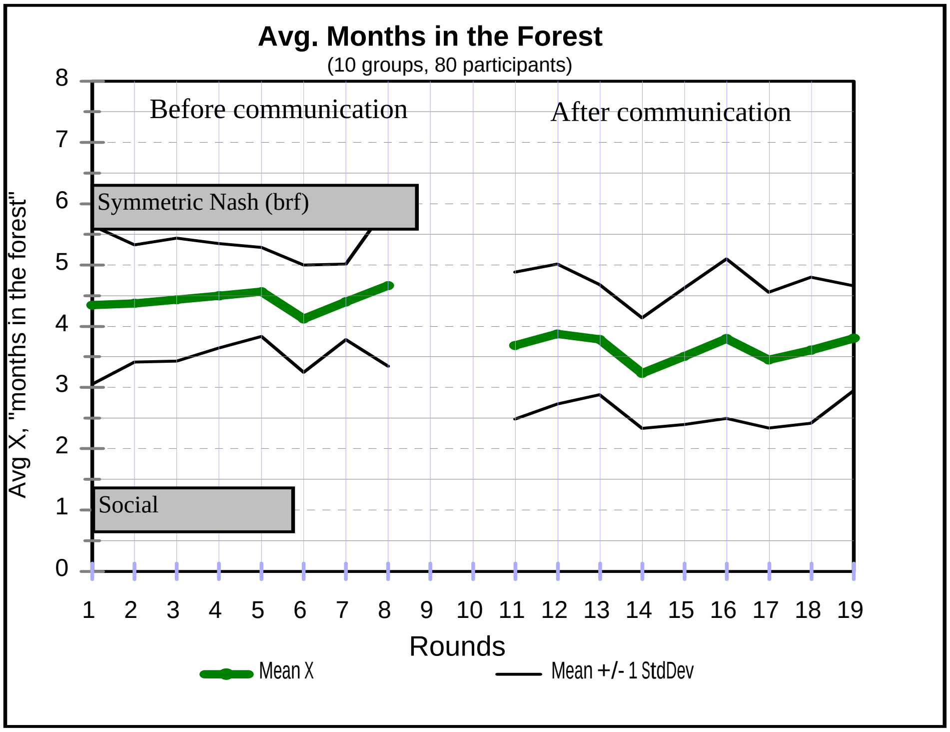

Figure 1. Average choice X_i over time for the 10 groups.

consistent with most of the experimental evidence in CPR and also other public goods experiments where while not achieving the social optimal solution, the groups do not fall to the symmetric Nash prediction of purely selfish individuals despite the incentives to free-ride[5].

[5] Recall that the optimal solution is achieved by each player "going 1 month to the forest", while the Nash prediction would bring such decision to 6 months.

Figure 1 shows the evolution of the mean and variability of X over time for the 10 groups. For rounds 1 through 8 the participants made their decisions individually and without communication within the groups. Beginning on round 11 and through round 19, all groups had 3-5 minutes for an open discussion before each round decision[6].

The figure shows, and the statistical tests confirm that in average face-to-face communication induced a slight change in individual behavior and created partial social gains for the groups. The average X_i, at the end of the non-communication rounds was at 4.39 months. The introduction of the communication by allowing the groups to have an open discussion between rounds induced on average a slight reduction of the average use of the commons down to 3.61 months at the end of the communication rounds. In Table A.1. in the appendix we provide details of the evolution of $X_{i,}$ and in Table A.2., statistical evidence of such reduction in average X_i. See particularly Tests 2 and 4 where the p-values are zero, showing the effectiveness in the short and long-run of face-to-face communication. Given that the distribution of X might not be normal, and that the variable X is not continuous, non-parametric Wilcoxon-Mann-Whitney tests were also performed to confirm the conclusion, mainly that face-to-face communication does have an impact in the level of cooperation, and that it sustains itself over rounds.

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[6] Some groups -but not all- did play rounds 9 and 10, as well as rounds greater than 19. This was made to avoid the problem of the players knowing which was going to be the last round in each stage. All groups played up to rounds 8 and 19 in each stage and these are the data we use for purposes of comparability in the analysis. However, within groups, we did not observe a significant change from what was happening at the end of each stage.

a. An index of cooperation (XDEVIA): Deviation from a Nash best response.

Using the symmetric Nash as a yardstick to compare with the average choice in a group is partially helpful as it does not tell much about the balance between self-regarding and other-regarding or cooperative behavior from the standpoint of each player. Therefore, we calculated at each round, and for each player what her Nash strategy would be if she were to follow an individual maximization strategy given what the others in the group chose. We call such deviation from the Nash strategy, $XDEVIA_i$, and we graph its evolution in Figure 2 by showing the average of XDEVIA over time[7]. In brief XDEVIA measures at each round how much the player deviated away from an

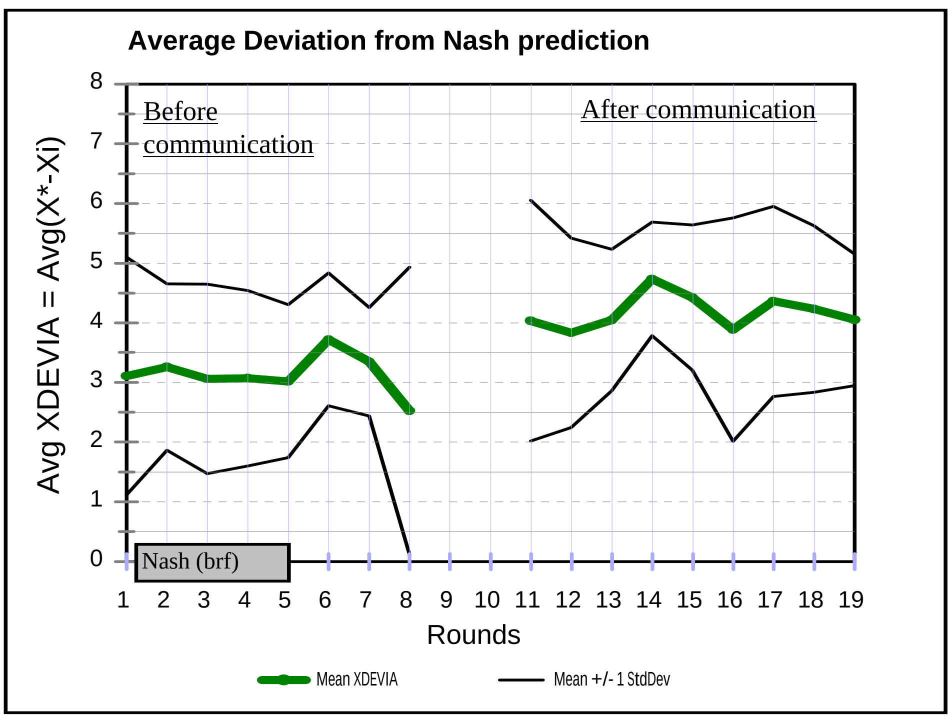

Figure 2. Average XDEVIA (Deviation from Nash) over time. 10 groups.

individualistic Nash strategy, and closer to a group maximization solution, i.e. it measures the

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[7] Another way to understand XEDEVIA is using the payoff table in Table A.7. XDEVIA is measured as the difference between the actual choice X_i and the X_{nash} which corresponds to the column of the highlighted cells.

willingness to cooperate by each player, given what the others are doing.

Clearly, communication induced an increase in such cooperation variable (See also Table A.2. for tests). Notice however the variability in the effectiveness of communication to increase cooperation. In Table A.3 report the averages by group for XDEVIA during the beginning and end of the two stages. Notice in that table for instance how XDEVIA ranged from 0.3750 to 5.8333 across the ten groups with a mean of 3.9667, showing the wide range of cooperation achieved at the end of the communication rounds.

Such increase in group oriented behavior and away from individualistic choices brought therefore an increase in individual and group earnings. We can appreciate such increase in earnings in Tables (A.1 and A.2.2) where we test the significance and the magnitude of the increase at the end of the communication stage. Nevertheless, we found a great variation in the social efficiency - measured as (actual group earnings / group earnings at the social optimal solution) achieved by the 10 groups, ranging from 46% to 89% in the first 3 rounds of communication, and between 29% and 93% at the end of such stage. Further, while the mean increase in social efficiency from the last rounds with no communication to the last rounds in the second stage was of around 11%, such efficiency change ranged across the 10 groups between -33% to 51%. This high variation found in similar experimental evidence led us to pursue the analysis that we present in the rest of the paper.

We video and audio recorded most of the rounds discussions, and an overview of these could explain roughly such variability. Some groups were able to find faster the optimal solution from the payoff table than others. Some groups had leaders in them that brought the group together to undertake a group maximization strategy. In some cases they were able to reinforce how bad it was for the group's earnings to have players choosing high values of X. However, some groups were not able to enforce a rule for all to follow such as “reduce X as much as possible” as some groups did. Further, other groups showed however very ineffective discussions, even to the point of not discussing at all the game and ways of making earnings improve, accepting the outcome round after round, and having conversations regarding other matters, or thanking the organizers for having this event in these far apart villages.

The variability of the effectiveness of communication in common-pool and public goods experiments remains a puzzle throughout the literature using the CPR design. OGW (1994: page 155) present for instance results for several experiments where group efficiency ranging mostly between 50 to 90 percent levels across six groups and even one with -15%, after 10 rounds of face-to-face communication.

4. What do people bring into the lab?

Although our statistical tests provide evidence that communication did improve partially social efficiency through a change in individual behavior towards a group oriented strategy, the variability of gains in efficiency across the 10 groups is intriguing. Since we have excluded the possibility that payoff asymmetries accounted for the variation, and given that the rules of communication were the same for all groups, we turn now to study other factors that may explain the variation.

Given that the subjects were members of actual communities, knew each other, and showed a variability of demographic and socio-economic characteristics, we wondered if these factors may have been brought into the field lab and affected behavior. We believe they did. There is also experimental evidence that while maintaining homogeneity of the payoff structures some factors created by the experiment through framing or extra information about the counter parts in a game induce changes in behavior. See Hoffman, McCabe and Smith (1996) and Kollock (1998) for two examples. Also, there have been some recent attempts to study if factors outside of the lab design may affect cooperating behavior such as student's major, gender or cultural background, with mixed results[8].

There are different institutional factors that may affect the willingness to cooperate by an individual, additional to the incentives to cheat or the gains from cooperation given by a payoff structure. Many of these institutional factors enter into play in the form of information that the players gather and use strategically either in a one-shot or in repeated games. Some hypotheses are emerging on the logical process in the individuals' minds, determined by the information they use and the context -the group- in which they are immersed in. McCabe and Smith (1988) propose a "cognitive model" to explain the use of information by the individual in the decision to cooperate or defect in these kind of dilemmas. Their model considers several modules that the individual use for processing information in the decision to cooperate or not with the other. The modules are i) friend-or-foe detection; ii) shared attention on mutual gains; iii) cheater detection; and iv) good will accounting.. These modules allow the individual to go through several filters before deciding to cooperate, when processing information such as whether the other can be trusted, if they both are aware of the mutual gains from cooperation, if the other may have sufficient incentives to cheat or if the goodwill of the players is used for signaling about cooperating.

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[8] Ledyard (1995) suggests that among the factors on group heterogeneity to play a weak role in determining cooperation in public goods experiments are "systemic" variables like training, beliefs and gender. For more recent evidence see Ockenfels and Weinmann (1999); Bram Cadsby, Charles and Elizabeth Maynes (1998); Kollock (1998); Brown-Kruse and Hummels (1999); Ortmann and Tichy (1999).

Ostrom (1998) on the other hand suggests that the virtuous cycle of reciprocity, reputation and trust, key for the emergence of cooperation in groups, is affected by factors like the development of shared norms, information about past actions and the existence of long time horizon for the relations, symmetry of interests and resources, the costs of arriving to agreements and the existence of face-to-face communication.

If individuals, when deciding to cooperate or defect, do pay close attention to who the others are in the social exchange, there should be other reasons involved in the decision besides the selection of a best response or Nash strategy based on the payoff structure. These other reasons involve information the individual gathers about the others. Laboratory experiments can be used to induce artificial changes in some of these factors such as recognition of the other from previous or the probability of future relations, or the availability of information about the others' actions.

We take the approach of studying if the real world of the subjects played a role in the triggering of reciprocity and cooperation among the players. Further, since these new models of rationality are suggesting that the context in which the individual is playing matters, that is, who are the others in the group, we were interested in looking at the group composition from the standpoint of each individual. This information could then explain part of the variability in the effectiveness of face-to-face communication among these groups. In other words, we could test if the real context and conditions of these subjects and the way they were grouped for the experiments, could confirm hypotheses such as the positive effect on cooperation of more homogenous groups in terms of interests or values, or the importance of goodwill from previous exchanges.

For doing this, we have performed a statistical analysis at two level. At a first more general (group) level, we study if the efficiency achieved by the groups at the end of the communication period may be correlated with the average composition of the groups in terms of their demographic or economic characteristics. Such inquiry in fact led us to go at a lower level where we model the individual decision at each round as a function of not only the environment of incentives and constraints created by the payoffs and the communication, but also as a function of the characteristics of the individual and the rest of her group. Such analysis produced even stronger results supporting the idea notion that wealth and inequality may have an impact in the way groups resolve conflicts in these kind of dilemmas.

a. A group level analysis.

Of several types of indicators, economic variables such as occupation, sources of income and wealth helped seemed to explain better the variability of the social efficiency achieved by the 10 groups[9]. A simple example is shown in Figure 3 where we plot the average social efficiency achieved by each group in the last 3 rounds of communication against the average real wealth of the 8 participants in the group[10]. We estimated the proxy for wealth by calculating the current local market value of the land, livestock and equipment owned by the household of the participant. In general we found that certain 'group composition' factors explained at some levels of significance part of the gains in group efficiency.

To perform this first set of tests we looked at simple correlation coefficients between group

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[9] Our first step was to study if basic demographic factors may explain part of the puzzle. Some could argue that the level of education, or age could have an effect in the way the decisions were made, or the way the game was understood, specially given the low levels of education to age for these villagers (See Table A.4. in the appendix). We found however no significant correlations at the group level between the average or variance of such demographic variables for each group and the individual decision making, or the group game outcomes.

[10] The group CEW41 in the graph deserves a note. This group was the least effective of all group under this treatment according to the tapes. They did not engage in any conversation that attempted to change the game decisions, and devoted this time to thanking the organizers for these activities, and to say that they "*were doing just fine and were learning a lot*".

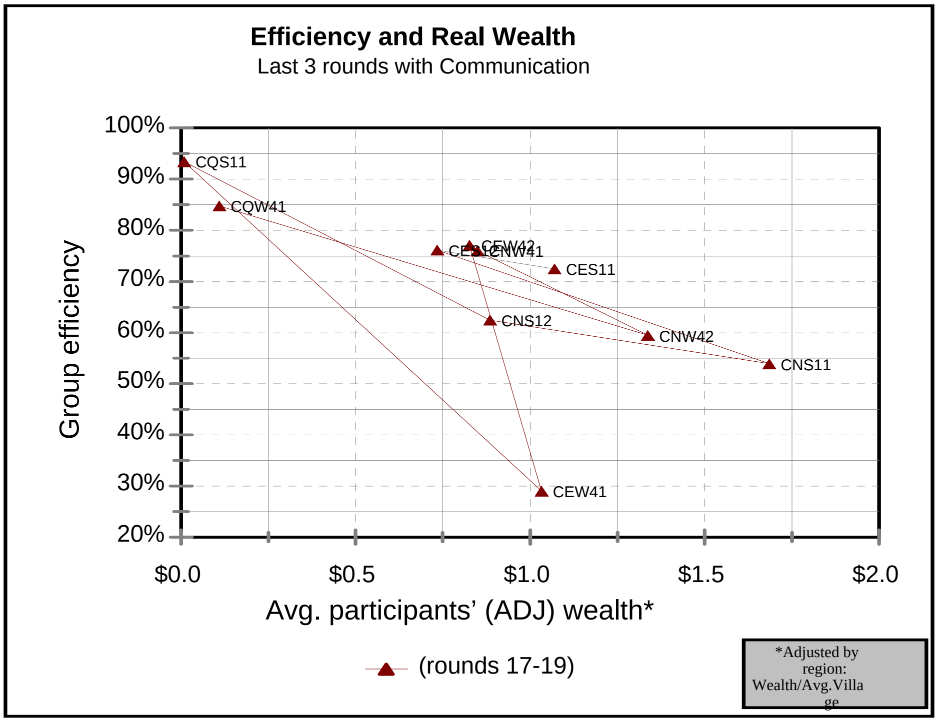

Figure 3. Group efficiency and group's average real wealth.

efficiency and group composition, as shown in Table 2 including the respective p-values. The 'group composition' variables are described within the table. We used the following different indices of social efficiency at group level. All these indices measure different aspects of gains in social efficiency from the face-to-face communication mechanism:

-SOCIEFA2 = Average social efficiency at the last 3 rounds of the first (non-communication) stage.
-SOCIEFB1 = Average social efficiency at the first 3 rounds of the second (communication) stage
-SOCIEFB2 = Average social efficiency at the last 3 rounds of the second (communication) stage
-SEFIA2B1 = Percentage change in social efficiency from the last rounds in the first stage (no-communication) to the first 3 rounds in second stage (communication).
-SEFIA2B2 = Percentage change in social efficiency from the last rounds in the first stage (no-communication) to the last 3 rounds in second stage (communication).

Variables	Group efficiency			Change in Group efficiency	
	(SOCIEFA2) Last 3 rounds No-COM	(SOCIEFB1) 1st 3 rounds COM	(SOCIEFB2) Last 3 rounds COM	(SEFIA2B1) Last 3 rounds No-COM -> 1st 3 rounds COM	(SEFIA2B2) Last 3 rounds No-COM -> Last 3 rounds COM
Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 10					
Percentage of individuals whose main source of income is extracting a common-pool resource:					
AVGINCEX	-0.36803	0.19775	0.31654	0.33970	0.46377
	0.2954	0.5839	0.3729	0.3369	0.1770
% of individuals whose main source of income is land based production:					
AVGINCLN	0.25832	-0.77442	-0.72040	-0.64200	-0.71558
	0.4712	**0.0085**	**0.0188**	**0.0454**	**0.0200**
% of individuals whose one of main labor allocations is on extracting a common-pool resource:					
AVGOCCEX	-0.28262	0.38295	0.52035	0.40759	0.57322
	0.4288	0.2747	0.1231	0.2423	**0.0832**
Percentage of individuals whose one of main labor allocations is on land based production:					
AVGOCCLN	0.39154	-0.49518	-0.49653	-0.54222	-0.61848
	0.2632	0.1456	0.1443	**0.1054**	**0.0566**
Average livestock based wealth:					
AVLVWLTH	0.25673	-0.19275	-0.42831	-0.27176	-0.48597
	0.4740	0.5937	0.2169	0.4475	0.1544
Average (land, livestock and equipment) wealth adjusted by local (village) prices:					
AVHHWLT2	-0.14397	-0.43993	-0.69399	-0.19555	-0.45885
	0.6915	0.2033	**0.0260**	0.5882	0.1822
Standard Deviation of (land, livestock, equipment) wealth:					
STHHWLT2	-0.29596	-0.23016	-0.59255	0.02607	-0.29025
	0.4064	0.5224	**0.0710**	0.9430	0.4159
Variance of Log(wealth):					
VARLWLTH	0.45089	-0.21776	-0.04549	-0.40061	-0.30019
	0.1909	0.5456	0.9007	0.2513	0.3994
Gini coefficient of wealth distribution:					
GINIWLTH	-0.10705	0.58187	0.52300	0.43173	0.47228
	0.7685	**0.0776**	0.1209	0.2128	0.1681

*p-values smaller than 10% are highlighted.

Table 2. Group level analysis: Correlation between group efficiency and group composition.

In general we can observe that occupation and wealth show a certain pattern of relations with the efficiency achieved by the groups during the communication rounds. The first column of Pearson coefficients, where we can see no patterns or strong significance, may confirm that most of the factors suggested to play a role here, entered into play during the communication stage. The small sample size is a constraint for getting p-values small enough, but the consistency of the signs is illustrating. Those groups formed by greater fractions of people whose occupation involve more extraction of a local commons, and those groups where wealth was smaller and more homogeneously distributed showed higher levels of group efficiency, and seemed to have achieved higher yields from communicating with one another.

There are several possible explanations for these partial associations. At least two seem relevant to the present discussion. One could argue that wealth reduces the probability that a person faces a local commons type of dilemma and therefore decreases the familiarity of the subjects with these conflicts when trying to solve them in the experiment. Poorer people may have had more frequent cases of facing the chance of cooperate or defect when contributing to a village project where free-riding is an option (lack of land, energy sources or equipment). And prior experience with extracting a commons may have facilitated some groups in solving the conflict[11].

The other plausible argument is that wealth, and particularly wealth differences in the group, may create enough social distance among the subjects that it becomes more difficult to produce a collective solution to the problem, namely, reducing $\sum x_i$., through simple communication. This last argument, however, seems weakly supported by the correlation data above. Notice, for instance, the

[11] In fact, the audio recordings show how some groups used daily life examples related to extracting firewood, hunting and fishing, when discussing why it was better to undertake a group maximization strategy.

opposite signs for measures of wealth distribution such as Gini, Variance of Log(wealth) and Standard Deviation of wealth.

5. A multi-layer analysis of the individual decision-making to cooperate.

The discussion and statistical results above lead us to a search for a micro-level set of factors that are determining the individual's decision to cooperate, beyond the pure calculation of monetary payoffs from each possible strategy, even if in a repeated game. We propose here a multi-layer framework to put together the key factors that the literature is discussing in attempt to provide the grounds for a model with which we can test some of the hypotheses discussed. Given that we have available data at the round, individual, and group levels for the institutional constraints of the experiment and the actual institutional setting that surround these subjects, we could attempt to estimate a multivariate regression of the individual decision in each round as a function of the different layers of the framework that follows.

In Figure 4 we propose a set of four layers of information or factors that an individual may use in her decision to cooperate or not in each round of a repeated game where there is a local commons type of dilemma. The decision to cooperate, according to the model, emerges from the processing information after crossing the four layers. In the first (static) layer of analysis the individual looks at the net benefits and costs of each feasible strategy that is allowed in the game and constrained by the enforced rules. This is the basic game theoretic argument based, for instance, on backward induction. In a second layer the player considers the dynamic context of the repeated game and incorporates, for instance, the possibility that her action in t may affect the actions of the others in (t+1) through retaliation or cooperation. Reputation and learning have been shown to play a role at this level in repeated games In the third layer there are considerations that the individual may bring into play such as her personal experience, or values about the environment, social exchange, or about the possibility of self-governed relations. In the fourth layer there are factors that additional to the other layers may induce changes in the willingness to cooperate. Group identity, group cohesion and social distance have been shown to affect the likelihood that the individual cooperates (Lawler and Young, 1996; Kollock (1998); Orbell, Dawes and van de Kragt, 1988; Alesina and La Ferrara, 1999).

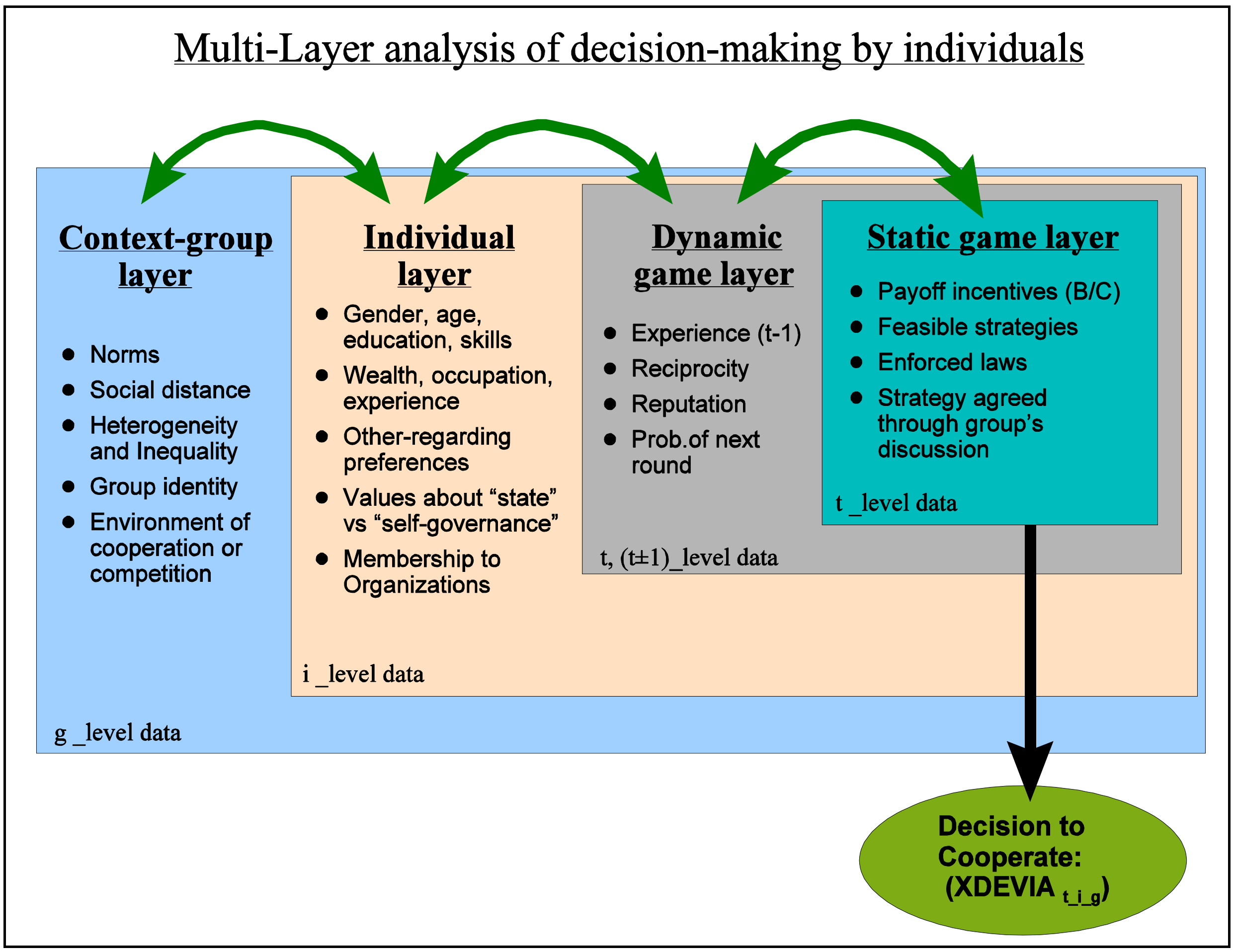

Figure 4. A multi-layer framework for analysis of individual decision-making.

Further, the model suggests also that factors in one layer induce changes in the way factors in superior or inferior levels affect cooperation. One example is that an n-prisoners' dilemma payoff structure in the first layer could be transformed into an assurance game payoff structure if one translates the monetary payoffs into subjective ones that account for other-regarding preferences present in the third layer, which in turn transforms the best reply strategy in the static game (Kollock, 1998). Another example is that the feasible strategies in the first layer may change by social norms created at the fourth layer. Or one could consider how factors in the group-context level, e.g. solidarity networks, do affect cooperation due to the nature of the repeated game in the second layer (Fafchamps, 1992).

For purposes of the focus of this paper, we will concentrate on the particular role of the individual and group layers, and how the real world variables may affect the experimental behavior. The data collected at the four different layers allowed us to test some of these hypotheses[12]. The estimated model is reported in the following Table 2. We model the decision XDEVIA in each round as a function of a vector of variables from the different layers discussed in Figure 4. The explanatory variables used were the following. In the appendix, Table A.6 shows their descriptive statistics:

Dynamic layer:

-DELTSUM7: Decrease of $\sum X_i$i by the rest of the group from previous round.

-XDEVIAL: It is XDEVIA lagged.

Individual layer:

-OCCULAND: A dummy variable, 1 if individual derives most of her income from land based production, 0 otherwise.

-BESTATE: A dummy variable from a multiple choice question on what the individual thinks is the best solution for managing the local commons from where they derive their firewood and other resources. The

[12] Notice the labels in the bottom-left corners of the layers. *t_data* refers to individual decisions made at each round by each indivudual; *t,t(±1)_data* pools these across rounds; *i_data* referes to variables measured for each individual which they reported in the survey at the exit of the game; *g_data* consists of individual data aggregated by each of the 8-person groups.

dummy is constructed by assigning 1 if she marked a government solution, 0 if marked any other solution including community, private or leave things as they are.

-HHWEALT2: Wealth for the individual's household based on land, livestock and equipment assets, valued at local market prices, and adjusted for village prices to allow comparisons across 3 villages.

<u>Context-group layer:</u>

-AVCOOPLB: Group's average of individuals' contributions in unpaid days of work to community projects.

-SEXDIST2: Gender distance between the player and the rest of the group. Calculated as abs(SEX - ((SEXSUM8-SEX)/7)), where SEX=1 if female, 0 if male.

-WLTHDS2A: Wealth distance estimated in the same fashion as the gender distance, as the absolute value of the wealth difference between the wealth of i and the average wealth of the other 7 players in the group.

-WLT_DIS2: Cross variable = HHWEALT2 * WLTHDS2A.

Dependent Variable: XDEVIA

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	10	1590.02594	159.00259	36.350	0.0001
Error	666	2913.25027	4.37425		
C Total	676	4503.27622			

Root MSE	2.09147	R-square	0.3531
Dep Mean	4.20236	Adj R-sq	0.3434
C.V.	49.76892		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|	Standardized Estimate
Static layer:						
INTERCEP	1	3.770037	0.39314742	9.589	0.0001	0.00000000
CEW41	1	-0.973274	0.41492238	-2.346	0.0193	-0.09103077
Dynamic layer:						
XDEVIAL	1	0.426551	0.03413444	12.496	0.0001	0.42896913
DELTSUM7	1	0.060196	0.01035776	5.812	0.0001	0.18444860
Individual layer:						
HHWEALT2	1	-0.468006	0.18522524	-2.527	0.0117	-0.20198042
OCCULAND	1	-0.448209	0.20326869	-2.205	0.0278	-0.08653878
BESTATE	1	-0.452089	0.18224517	-2.481	0.0134	-0.08452538
Group-context layer:						
AVCOOPLB	1	0.080885	0.03597458	2.248	0.0249	0.09216744
SEXDIST2	1	-1.062445	0.35793905	-2.968	0.0031	-0.09851988
WLTHDS2A	1	-0.863374	0.20690368	-4.173	0.0001	-0.26032942
WLT_DIS2	1	0.255178	0.07979002	3.198	0.0014	0.31240318

Note: We have included a dummy for the CEW41 group mentioned in a previous footnote. The results do not change significantly if excluding these data in the estimation.

Table 3. OLS regression results for the multi-layer model of cooperation.

a. Discussion of the regression results.

The overall performance of the estimation supports the idea that the model can explain a fraction, around a third, of the variability of the dependent variable XDEVIA as a proxy for cooperation in each round, by each individual in each round[13]. The set of independent variables are significant explanatory estimators although there might be others not modeled here that could explain the remaining fraction of variation of XDEVIA not explained here[14].

The estimation results presented above can be summarized by looking at the set of variables in each layer. First of all, we should remind the reader that the estimation results from using the data for the rounds played under the face-to-face communication stage only. It is here where we believe a lot of the effects at the superior layers are triggered. In fact the same estimation for the data on the first stage yields poorer results in terms of overall performance.

Let us start with the estimators for the third and fourth layers given that they involve the most relevant results for the focus of this paper, that is, the effect of wealth and inequality on cooperation. Wealth (HHWEALT2), by itself, reduces the level cooperation with the rest of the group during the communication rounds. There is a cross effect of wealth with wealth distance that we discuss later. We have argued that individuals with better assets might have less frequent social interactions dealing with these kinds of dilemmas with those in their group. Ben-Porath (1980) and Bowles (1998) suggest that wealth makes individuals reduce their interpersonal connections and increase their market exchange. The same argument would hold for the case of the negative sign of OCCULAND, which although partially correlated with wealth, is not equivalent given that it tells whether the main occupation for the individual is working individually on the land but not necessarily owning it.. The negative and significant coefficient for BESTATE, a proxy for the

[13] The sample size, 676 observations, is the aggregation of 10 groups x 8 players x ≈9 rounds each group played under communication for the second stage. Some of the groups played less others more than 9 rounds.

[14] For instance one could study in more detail the types of agreements and discussions for each round and each group to account for types of group discussions.

individual's preference over "state" rather than decentralized solutions also presents interesting results as it suggests that those who value more the self-governed forms of conflict resolution where more prone to cooperate.

At the fourth layer we found again results that could expand our understanding of the factors impacting the effectiveness of communication in groups. The positive sign of AVCOOPLB suggests that cooperation emerged more easily in groups where there is a tradition of cooperators in the real world and could suggest that the familiarity of these individuals in donating labor to the community could make the resolution of the dilemma in the experiment easier. In the case of social distance we find two interesting effects. A gender distance (SEXDIST) which we can interpret by saying that the individual was less likely to cooperate for groups where her gender was a majority. And in the case of wealth distance (WLTHDS2A), again a negative and significant value implying that the absolute value of the wealth between the individual and the average wealth of the other seven participants in her group decreased the willingness to cooperate.

A significant cross-effect of wealth and wealth distance (WLT_DIS2 = HHWEALT2 * WLTHDS2A) suggests an interesting factor in the decision making of the individual. Its positive value suggests that the marginal effect of wealth distance -which we know is negative- is stronger for poorer than wealthier people in the group. In other words, although the less wealthy people are more likely to cooperate (see sign of HHWEALT2) they reduce such willingness to cooperate if the wealth distance is very large. Mathematically it could be the case that, for instance, the marginal effect of wealth or wealth distance on cooperation turns positive, but this would happen for values way beyond the actual range of values for the sample[15].

Finally, a look at the last column of "standardized estimate" coefficients, can provide some additional information of the relative weight that each variable has on XDEVIA because of the differences in scales and units. Notice how the wealth related variables, and despite collinearity problems among them, remain among the most important. Further, the social distance seems to be the second most important after the lagged effect at the dynamic layer.

We have considered the dynamic and static layers of the game in the estimation by including several variables as proxies for some of these determinants to cooperate. We could interpret the positive value of the intercept and the significance of XDEVIAL as an overall tendency of the individual to stay away from the Nash best response -despite the incentives to free-ride, but at the same time concentrate on a certain sub-range of X, other things being controlled for. Finally the positive and significant coefficient for DELTSUM7 confirms the general finding that reciprocity is well and alive during the communication rounds. The results suggest that the individual responds with higher cooperation (XDEVIA) to a decrease in the aggregate use of the commons ($SUMX7_{(t-1)}$ - $SUMX7_t$) by the other seven players in the group. In other words, if the communication prior to the decision was effective enough to induce a reduction in $\sum X_i$, the best response for the individual would be to increase X and earn higher yields. A reciprocant, however, would follow such reduction with lower X, that is higher XDEVIA.

In general these findings have a common thread of familiarity and dependence on local commons as key to trigger cooperation during the communication rounds. Groups made of people

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[15] For instance, for the coefficient of wealth distance (WLTHDS2A) to become positive, one would require that HHWEALT2 > 0.863374/0.255178 = 3.383 which is way beyond the range of this variable (the mean and std.deviation for HHWEALT2 are 0.834 and 1.115 respectively.

more familiar and more dependent on common-pool resources (those with less land, less livestock and more extraction of the commons) seemed to have achieved higher levels of social efficiency in the experiment. Land production assets do provide individuals with better income options but takes them away from dealing in their daily lives with local commons dilemmas.

But further, the composition of the rest of the group matters, and significantly, from gender to wealth, the results suggest that the fourth (group-context) layer of the framework is powerful in predicting the behavior of the individual, independently of the other layers involved. Given that the payoff structure and the incentives to defect and play a Nash best response are clear and exaclt the same for all 80 participants, these results suggest that the other layers of the decision-making played a role in determining in each round the decision to deviate from an individual maximization and towards a group maximization strategy.

6. Conclusions on the problem of inequality and heterogeneity.

Some authors have argued that the presence of wealthier members in a group can have positive effects in making collective action succeed. Olson (1965) and Bergstrom, Blume and Varian (1986) are seminal works with grounds for such arguments. Other important field-based works like Ostrom (1990) and Wade (1994) also conclude that the presence of wealthier individuals, if their interest is aligned with the group's, can even promote cooperation and collective actions in rural villages[16]. Leadership, higher marginal returns from the private provision of public goods, political connections to state funds and legislators and education are all reasons why a group can benefit by having wealthy members. But in all of these arguments it is common that the marginal returns for

[16] Wade's set of propositions include the following: *"the more powerful are those who benefit from retaining the commons, and the weaker are those who favour sub-group enclosure or private property, the better the chances of success" (1994: pp. 216).*

the rich from the provision of the public good is positive and proportionally greater, which basically the Olsonian proposition of the privileged group.

However, if the production function of the public good and the preferences of the wealthy are not as aligned, the effect of wealth in making collective action happen might change and even switch signs. Problems of information asymmetries and costs of designing clear contracts enhance this problem. Bowles and Gintis (1998), Baland and Platteau (1996ab, 1997ab, 1998), Sandler (1992), De Janvry (1998) provide theoretical grounds for this negative effect, or a quadratic one (Dayton-Johnson and Bardhan, 1998). Chan et.al. (1996) provide experimental evidence qualifying the Bergstrom, Blume and Varian (1986) prediction that income increases voluntary contributions to public goods. Several other experimental works contest that voluntary contributions to public goods have a monotonic relation with wealth or income (Ledyard (1995), Hackett, Schlager and Walker (1994), Isaac, McCue and Plott (1985), Chan et.al., 1996). Bardhan (1999), Dayton-Johnson (1999) and Molinas (1998) have empirical evidence on the quadratic relation between inequality and cooperation in irrigation systems in India. Narayan (1995) also shows econometric evidence from 121 rural water supply projects executed by 18 different aid agencies in Asia, Latin America and Africa, suggesting that poverty is not a requirement for an effective collective action in managing rural water supply systems.

On the other hand, cooperation by others besides the wealthy is also possible, and there exists wide evidence of it despite the argument based on free-riding that the poorer would not contribute and would wait for the privileged ones to do it. Wade's 'village republics' has become a seminal work on this view and experiments and field studies support this notion.

Our analysis of the effect of group heterogeneity on experimental cooperation allowed us to isolate ourselves from the case of a positive effect of inequality and cooperation due to asymmetric interests in providing the collective good. We have done this because the marginal returns from cooperation in the experimental design is symmetric for all eight players in each group. This leaves us with the effects of cooperation and free-riding on non-monetary incentives and preferences. And they confirm that the third and fourth layers regarding the individual and the group or context matter. For instance social distance created by real wealth inequality reduced the level of cooperation in a group and at the individual level, as shown by the regression estimation. The result somehow gains strength considering that other demographic characteristics of the individuals and the groups (e.g. variables like education, gender or age) were not powerful explanatory variables of experimental behavior in pre-testing estimations. In other words, who you are playing with (or against), besides who you are and what is at stake in the game, matters in determining your willingness to cooperate. Two concluding propositions could be derived from the results:

First, the effectiveness of community self-governance mechanisms such as face-to-face communication for solving local commons dilemmas maybe constrained by the social distance created from unequal distribution of wealth among group members.

Secondly, levels of wealth and occupations associated with economic activities based on individualized production and therefore requiring less use of social networks such as when using common-pool resources may decrease the likelihood that self-governance mechanisms induce cooperation through the virtuous cycle of trust, reputation and reciprocity. If wealth increases the fraction of people's transactions that are based on markets, their experience in social exchange is more influenced by competitiveness and self-regarding behavior than the experience of those whose income is more dependent on relating to others through collaboration, sharing and other cooperative traits.

It should not be interpreted, however, that the net effect of wealth and wealth inequality on cooperation will always be negative. What is being argued here is that the capacity of groups to overcome the local commons dilemma through self-governance mechanisms is being constrained because communication seems to have been more difficult for more heterogenous groups, or groups made of people less familiar with local commons dilemmas, all of which are affected by their private ownership of assets. Wealth plays many other roles in the provision of collective goods and determines other factors in the preferences of the individuals, in their individual production functions and in the local commons production function. All these forces of course act in the real world along with the arguments that wealth also can motivate cooperation if the privileged group condition holds. Which overpower the other one should be motivation for further field, experimental and theoretical research. Introducing inequality in the field experimental design might be one possibility and then study how the two forces interact, that is, the motivations to cooperate when the public good provides higher returns to the wealthy against the impediments created by social distance and lack of group identity.

7. A Final Note on the power of field experiments

The trend in using experiments in economics to study human behavior in different types of social exchange has brought concern over whether experimental economics can really explain the more complex real world. Loewenstein (1999) argues in a recent "Economic Journal" issue devoted to this question that experimental economics has not "*...been able to avoid the problem of low external validity that is the Achilles heel of all laboratory experimentation" (pp. F33).* Loomes (1999) as organizer of this EJ issue also highlights *"the dangers of constructing experimental* *environments so stripped of context that participants search desperately for cues about the kind of behavior that might seem sensible, or that they think the experimenters might be looking for, with the result that they fail to process the tasks as they would do in the richer social environment we may be seeking to model*" (pp. F3).

Our field experiment along with collection of data for learning more about our subjects attempts to avoid some of these dangers. The results have shown that the real world environment does play a role in determining the way people will behave in the experiment. However, the way the real world variables entered into the experiment's results is more complex than just saying that people's background, economic activity or demographic characteristics determine people's level of cooperation or free-riding in our model. These elements acted in a more complex way, as they do in reality, by having an effect "in context", that is, depending on the group composition. We have shown that not only the variables associated with the individual's real world may explain part of the behavior, but also, the composition of the group in which the player took the decisions. The face-to-face communication institution created an environment for many of these elements to enter into play. In fact the same data set and model lacks power and explainability if using the data for the rounds before communication was allowed.

A lot of experimental work is still unsuccessful in explaining human behavior in the lab even when introducing sophisticated tools such as dynamic effects, learning and others in the existing game theoretical literature. Although a great deal of experimental evidence in decentralized markets with competitive conditions has shown a lot of predictability, most of the experiments in social externalities like public goods, voluntary contributions and common-pool resources still face the challenge of explaining the contradictions in the experiments. The data we collected on the participants' real world helped explain the variability of the experimental results that could not be explained by the experiment design and institutions introduced in the treatment. Further, it allowed us to test if the experimental outcome would predict similar situations in their real world behavior. The field provides us with a much greater variability in the variables of interest here, such as wealth, occupation, background, and values so that we can test these in an experimental setting. Further, the field could provide, at least for these type of group externality problems, a more natural and familiar setting for the subjects with respect to the problem being studied by the experimenter. However, the lab experiments as conventionally performed with students can provide a cleaner set of data and control more for other disturbances. We believe there is a complementarity of the two.

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Appendices

A.1. Main decision and outcome variables
A.2. T-tests and Non-parametric tests for differences in decisions and outcomes
A.3. Variability of decisions and outcomes across 10 groups
A.4. Demographic characteristics of participants
A.5. Economic activity and wealth of participants
A.6. Descriptive statistics for variables in regresion analysis
A.7. Payoff table (Symmetric game)

Table A.1 Games decisions and outcomes by period

PERIOD[a]	N Obs	Variable	Nmiss[b]	Minimum	Maximum	Mean	Std Dev
			BEFORE COMMUNICATION:				
A1	240	X	0	0.0000	8.0000	4.3875	2.2602
		Y	0	46.0000	795.0000	368.1667	145.5729
A2	240	X	8	0.0000	8.0000	4.3879	2.4309
		Y	8	28.0000	755.0000	371.4095	136.9657
			AFTER COMMUNICATION:				
B1	240	X	0	0.0000	8.0000	3.7833	2.4637
		Y	0	60.0000	783.0000	444.4667	149.6727
B2	240	X	16	0.0000	8.0000	3.6161	2.6406
		Y	16	111.0000	905.0000	460.1384	146.0009

Notes: N=10 groups x 8 players x 3 rounds = 240.
(a) Periods:
A1: First 3 rounds with no communication (Rounds 1-3)
A2: Last 3 rounds with no communication (Rounds 6-8)
B1: First 3 rounds with communication (Rounds 11-13)
B2: Last 3 rounds with communication (Rounds 17-19)
(b) One group did not play the entire set of rounds in period A2 and B2.

Table A.2.1.

Variables means by period:

VARIABLE	Periods during games: Before communication A1=(1-3)	A2=(6-8)	After communication B1=(11-13)	B2=(17-19)
X	4.388	4.388	3.783	3.616
XDEVIA	3.146	3.224	3.975	4.223
Y$ ($/round)	$368.17	$371.41	$444.47	$460.14
No. Observ	240	232	240	224

Table A.2.2.

Comparing across periods.

p-values[a] (t-tests for mean differences)	Test 1 (A1->A2)	Test 2 (A2->B1)	Test 3 (B1->B2)	Test 4 (A2->B2)
X	0.998	0.008	0.481	0.001
XDEVIA	0.733	0.002	0.319	0.000
Y$ ($/round)	0.803	0.000	0.255	0.000
p-values Wilcoxon test on X[b]:		0.007	0.387	0.001

Notes:
(a) Probability that the difference between the two means is zero. Equal variances assumed.
(b) Probability of false rejection for the NonParametric test (Wilcoxon-Mann-Whitney Rank Sums test)

Appendix A.3 Variability of decisions and outcomes across groups

Variable	N	Minimum	Maximum	Mean	Std Dev
Average XDEVIA by Period:					
AVGXDA1	10	1.6250	4.9167	3.1458	1.1306
AVGXDA2	10	1.3750	4.9583	3.2396	1.0809
AVGXDB1	10	1.8750	5.3750	3.9750	1.1292
AVGXDB2	10	0.3750	5.8333	3.9667	1.4964
Social efficiencies by Period:					
SOCIEFA1	10	0.3800	0.8234	0.5708	0.1515
SOCIEFA2	10	0.3793	0.8182	0.5774	0.1364
SOCIEFB1	10	0.4601	0.8933	0.6891	0.1488
SOCIEFB2	10	0.2909	0.9349	0.6852	0.1820

Table A.4. Demographic characteristics of participants

Variable Description	Variable	N	Minimum	Maximum	Mean	Std Dev
Dummy: 1 if Female	SEX	80	0.0000	1.0000	0.4750	0.5025
Age (years)	AGE	79	16.0000	76.0000	37.2278	14.2388
Years of schooling	EDUCATIO	79	0.0000	14.0000	3.3924	2.7984
1 if extracting resources is part of main 2 occupations[(a)]	OCCUEXTR	80	0.0000	1.0000	0.2250	0.4202
1 if cultivation or livestock is part of main 2 occupations	OCCULAND	80	0.0000	1.0000	0.5625	0.4992
1 if wage laboring is part of main two occupations	OCCUWAGE	80	0.0000	1.0000	0.4250	0.4975
1 if studying is part of main two occupations	OCCUSTUD	80	0.0000	1.0000	0.0500	0.2193
1 if firewood is the main energy source for household	FWOODMAI	80	0.0000	1.0000	0.6250	0.4872

Notes: [(a)] Extracting resources refers to fishing, logging, hunting, firewood extraction, etc.

Table A.5. Economic activity and wealth

	Variable	N	Minimum	Maximum	Mean	Std Dev
Dummy: 1 if extracting resources is the main source of income for the housheold	INCOEXTR	80	0.0000	1.0000	0.1500	0.3593
1 if land-based production (crops and livestock) is main income source	INCOLAND	80	0.0000	1.0000	0.3750	0.4872
1 if wage labor is the main income source	INCOWAGE	80	0.0000	1.0000	0.2250	0.4202
Estimated land owned value (in $millions) [(a)]	LANDWLTH	80	0.0000	31.6500	3.6967	7.2794
Estimated livestock value[(a)]	LVSTWLTH	80	0.0000	6.0000	0.8559	1.4563
Estimated equipment value[(a)]	MACHWLTH	80	0.0000	6.3000	0.4638	1.1048
Total economic assets value (Sum of land+livestock+equipment value)	HHWEALTH	80	0.0000	33.9500	5.0164	7.5899
No. of community organizations the participant belongs to [(b)].	PARTORGS	80	0.0000	5.0000	1.4000	1.0626
No. of unpaid labor days she contributed to last year.	COOPLABR	80	0.0000	30.0000	6.0625	7.6230
Estimated % of household income derived from extracting resources	LC_INCOM	80	0.0000	1.0000	0.3250	0.3567
Estimated % of household labor allocated into extracting resources	LC_LABOR	80	0.0000	1.0000	0.2750	0.3571
Estimated % of resources extracted that were sold to the market	LC_MARKT	80	0.0000	1.0000	0.2438	0.3421

Notes:

(a) The survey gathered data on land area owned, # of animals by type (cattle, horses, pigs, etc), and equipment owned. We multiplied by average local prices for these. Values are in $Millions pesos. At the time the exchange rate was around $1,300 pesos/US$.

(h) The organizations included local school board, *"Junta Accion Comunal"*, Community Councils, local cooperatives, and "others" such as religious groups.