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Analysis

Breaking the elected rules in a field experiment on forestry resources

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ABSTRACT

Harvesting from common resources has been studied through experimental work in the laboratory and in the field. In this paper we report on a dynamic commons experiment, representing a forest, performed with different types of communities of resource users in Thailand and Colombia, as well as student participants. We find that all groups overharvest the resource in the first part of the experiment and that there is no statistical difference between the various types of groups. In the second part of the experiment, participants appropriate the common resource after one of three possible regulations is elected and implemented. There is less overharvesting after the rules are implemented, but there is a significant amount of rule breaking. The surprising finding is that Colombian villagers break the rules of the games more often than other groups, and even more so when they have more trust in members of the community. This observation can be explained by the distrust in externally proposed regulations due to the institutional and cultural context.

1. Introduction

Communities are frequently able to govern their shared resources despite the temptation to overharvest (Ostrom, 1990). A tragedy of the commons is frequently avoided if resource users have the ability to participate in decision making on regulations and if there is graduated sanctioning, monitoring and enforcement, and trust among the resource users.

Experiments in the laboratory and field have shown that without communication and without costly sanctioning groups will overharvest the common resource (Janssen et al., 2010; Ostrom, 2006; Ostrom et al., 1992). However, allowing participants to communicate and/or sanction others at a cost to themselves leads to more cooperative results (Cardenas, 2001; Janssen et al., 2010; Ostrom, 2006; Ostrom et al., 1992).

Notably, rules imposed by the experimenter which are designed to improve the performance of the groups do not always lead to better performance (Ostrom et al., 1992). This is also observed in field experiments (Cárdenas et al., 2000; Vollan, 2008). One explanation for this is the crowding-out behavior of group-oriented decisions that are initially made because of intrinsic motivations, but due to external interventions, end up with behavior that is more self-oriented. Crowding-out of pro-social behaviors has been found in various social dilemma situations. A classic example is blood donations. Titmuss (1970) found that voluntary arrangements in the UK led to higher quantities and quality of blood donated than the incentive-based US system. Donating blood is often done because of intrinsic motivation, not because of financial rewards.

Vollan (2008) found that external interventions that are enabling instead of restricting reduce the likelihood of crowding out. Furthermore, he found that the more people support the new regulation, the higher the compliance.

In this paper we describe a series of experiments in which participants had to elect a regulation from a limited set of possible institutional arrangements. We analyze whether the elected rules lead to better performance and how compliant the participants are. The field experiments are performed with actual resource users in Colombia and Thailand and we will show that the results depend on the social context of the participants.

The experiments presented in this paper are part of a larger study that focused on understanding the role that experience with resource management plays on decisions made in a common pool resource game (Cardenas et al., in press). Experiments framed as forestry, fishery and irrigation dilemmas were performed in rural villages and urban university campuses in Colombia and Thailand. Participants were randomly drawn to participate in only one of the experiments. The rural villages had forestry resources, fishery or irrigation as the main common resource uses. In each village each of the three games was performed. We also performed return visits, a

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year after the original experiments, to discuss the experimental results, to perform role playing games, and do ethnography which helped to interpret the findings of the experiments. This paper discusses the forestry experiments. Irrigation experiments and fishery experiments are discussed elsewhere (Castillo et al., 2011; Janssen et al., 2012).

The experiment is a dynamic game to represent resource dynamics over time. Such experiments have been performed in laboratory settings (Herr et al., 1997; Janssen et al., 2010; Osés-Eraso et al., 2008) but to our knowledge not yet in a field experiment.

Despite doing experiments with resource users in the field we are aware of the mixed findings on the interpretation of observed behavior in the experiments and the actual behavior of the participants. Voors et al. (2012) report that experimentally measured tendencies to cooperate in an experiment in Sierra Leone does not correlate with actual behavior derived from survey responses. On the other hand, Rustagi et al. (2010) find that behavioral types from experiments explains performance effects of the communities in the physical change of forest management in an Ethiopian study. Because of the challenges of interpreting experimental results we combine field experiments with additional qualitative information derived during a return visit.

The rest of the paper is composed as follows. In Section 2 we present the experimental design, as well as four specific hypotheses we test in this study. Section 3 describes the context in which the experiments took place and Section 4 the experimental results. Qualitative results of field work which supplement the experimental results are described in Sections 5 and 6 concludes.

2. Experimental Design

The common resource is a dynamic resource representing a forest (see Appendix A for the instructions of the experiment). Each round participants can extract trees, and there is a limited regrowth of the forest. The initial amount of the resource is 100 trees. In each round each of the five participants can take a maximum of 5 trees from the resource (Table 1). The game has a maximum duration of 10 rounds. The stock will regenerate in each round. For every 10 trees remaining in the resource, one tree is added as regrowth, with a maximum resource size of 100 trees. When the stock is below 25 trees, the maximum number of trees each individual is allowed to extract is given in Table 1.

When participants collect as much as possible as fast as possible, the stock will be depleted in 5 rounds, and the trees collected by the group are 115. When they cooperate and maximize the group earning over the 10 periods, the group total can increase to 165 by harvesting just 10 trees per round in the first five rounds, before increasing the harvest rate (Fig. 1).

After ten rounds the participants must vote for one of the three following rules, which will be enforced for another ten rounds, and restarting with a 100 units resource:

- *Rule 1* (*Lottery*). Each round two participants are randomly drawn who can harvest. If somebody harvest when (s)he is not allowed to do so, a penalty may be applied. In each round a die is thrown, and when a six is thrown, an inspector comes and rule breakers get a penalty. The penalty consists of paying back the harvested amount plus an extra 3 tokens.
- *Rule 2* (*Rotation*). A fixed schedule is defined where two participants are allowed to harvest each round. In round 1, A and B can harvest, then C and D, then E and A, etc. The same mechanism of monitoring and sanctioning is used as rule 1.
- *Rule 3* (*Property*). Everybody has the right to harvest 0, 1 or 2 units per round. If a higher amount is harvested, a die determines whether the participant is inspected, and if in violation returns back the harvest plus 3 tokens.

Table 1
Maximum harvest table.

Current resource level	Individual maximum harvest level
25–100	5
20–24	4
15–19	3
10–14	2
5–9	1
0–4	0

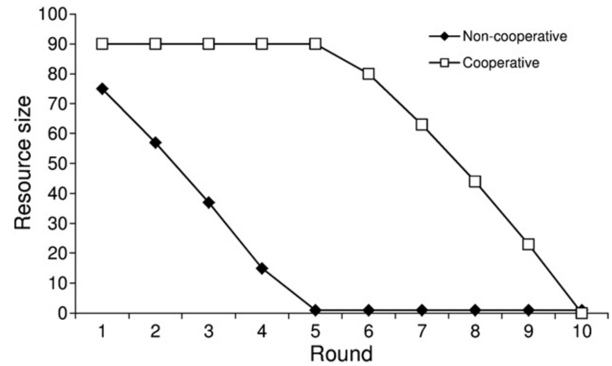

Fig. 1. Resource size patterns for non-cooperative and cooperative equilibria.

These rules were designed based on the most common rules found in field studies on common-pool resources (Janssen et al., 2007; Schlager et al., 1994). In our design, participants must vote for their preferred rules which will be implemented in a subsequent series of rounds if three or more players vote for it. If two rules get two votes, an additional round of votes between those two candidates is used to determine the final chosen rule. All rules are aimed at solving the resource dilemma by regulating the over-extraction of the resource in the appropriation stage, and thus achieving the goal of sustaining the resource through all ten rounds and each of the five players harvesting an equal share of the resource over the duration of the game.

Ten rounds are played with the new rule implemented. The first round after the election has the same starting situation as round 1 of the experiment. If participants are selfish and rational the non-cooperative equilibria would be the same. The reason for this is that expected earnings by breaking a rule are higher than complying with the rule. For rules 1 and 2 the expected penalty for breaking a rule is 8/6 while gaining 5 tokens if one is not allowed to harvest. For rule 3 the expected penalty is again 8/6 but this time the gain is 3 tokens. Due to penalties, the expected group earnings in the non-cooperative equilibrium are reduced to 96 for rules 1 and 2, and 81 2/3 for rule 3. The expected level of penalties for rules 1 and 2 is equal to have each round 3 players a 1/6 probability being caught and pay 8 (5 + 3) tokens for the first four rounds and 6 (3 + 3) for the last round before the resource is depleted. This leads to an expected penalty of 19 tokens. For rule 3, 5 players have each round the risk of being caught. This leads to an expected penalty of 33 1/3 tokens.

If the rules are followed, the resource size declines only slowly (Fig. 2). Since the resource is not fully depleted when the experiments end, the total earnings are 100 trees for all three rules. This is higher than the Nash equilibrium. If a group was able to coordinate to increase its earning, a profitable strategy would be to follow the rules for 6 rounds, and then harvest the maximal level for four rounds. This would lead to expected earnings of 144 for rules 1 and 2, and 123 1/3 for rule 3.

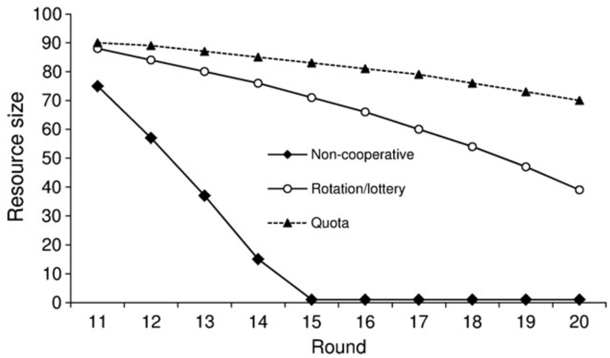

Fig. 2. Resource size patterns for non-cooperative equilibrium and for the cases the rules are followed.

It is important to note that with the rules implemented there is a temptation to break the rules. The expected benefit from breaking the rules is higher than the expected costs of getting caught as described above. The reason for this is the actual low monitoring rates in actual field sites by external monitors. Hence we should not expect to see a difference between the first 10 and the second 10 rounds.

The experimental design has been pretested with university students and farmers in rural communities before we performed the actual experiments reported here. We spend ample time – using visual aids and examples – to make sure participants understand the experimental design.

Based on earlier studies we define the following hypotheses for our study. The first two hypotheses are general to common-pool resource studies. The second two hypotheses are more focused on our specific study.

Hypothesis 1. Participants' path of extraction will follow the Nash prediction. Participants overharvest in each round of the game and exhaust the renewable resource as rapidly as possible.

In the experiment, participants are not able to communicate, and the personal benefit from extracting one unit is much greater than the expected benefit of leaving it on the ground, we expect that groups will overharvest the common resource inducing a net social loss for the group. The hypothesis is in line with the findings with a series of classic common pool resource experiment where participants extract on average the Nash equilibrium when participants cannot communicate or use costly sanctioning (Ostrom et al., 1992).

Hypothesis 2. Regulations lead to less overharvesting.

After the participants have elected a regulation, participants will reduce the average harvesting rate, either because the regulation works as a coordination device or because it imposes a private cost to violators. Cárdenas et al. (2000) and Vollan (2008) found improvement of the performance in common pool resource games when rules were imposed with probabilistic monitoring. As discussed in the introduction, imposed regulations may experience a crowding out of cooperative behavior. Since the rules are elected by the participants, we do not expect crowding-out behavior.

In earlier studies we find both evidence for the role of resource relevant experience and the social context of the village (Castillo et al., 2011; Janssen et al., 2012). Therefore we will test whether resource management related experience affect decisions made in the experiment versus the trust in other community members. If trust in others is the determining factor it is still possible that the specific biophysical context and resource management affect the conditions of community members to develop trust relationships.

Hypothesis 3. Relevant resource management experience affects the behavior in the experiments.

Janssen and Ostrom (2008) show that different experiences in controlled experiments lead to different rules crafted during communication rounds. In field experiments on common-pool resources, studies have found variations in actions in the experiments that can be explained by the differences in actual resource management experienced by the participants (Castillo et al., 2011; Ghate et al., 2013; Prediger et al., 2011), although in others no effect was found (Janssen et al., 2012). Based on the diversity of other studies we expect differences between experiments performed in villages performing forestry, in other villages, and with student groups.

Hypothesis 4. Trust in other community members affects the behavior in the experiments.

Based on results in other field experiments (and general findings of Poteete et al., 2010) we expect that more trust in others in the community will be a predictor of higher cooperative behavior, due to expectations of higher cooperation by other group members. In Janssen et al. (2012) irrigation experiments were analyzed from the same villages as this study, and trust explained the level of initial investments in the public infrastructure. However, we did not found a significant effect of trust on the decisions of the participants in the fishery games played in the same villages (Castillo et al., 2011).

3. Experimental Setting

The pencil and paper based experiments were held in six villages in Thailand and Colombia: three in each country. The reason for choosing those countries is the existing collaborations among the authors who work already in Thailand and Colombia which made it possible to perform experiments with communities who have day-to-day resource management experience at a local level. In one of the villages in each country the dominant resource use is a fishery, one a forest, and one an irrigation system (see Table 2). In Thailand, the experiments were performed in three separate locations of the Petchaburi watershed, which runs toward the west coast of the Gulf of Thailand. One of the villages is located is in the coastal area, and the other two are inland. The Colombian experiments were conducted in three different rural sites. The fishery community is represented by a village on Barú Island (a rural area of Cartagena, on the Caribbean coast). The irrigation community is located in the Fuquene lake basin area, located in the Andean region of Cundinamarca and Boyacá. And the forestry community is located in Salahonda, on the Pacific coast tropical forest area. For all these locations permission was given when needed by the heads of villages to perform experiments. The experiments were held during the first six months of 2007. Typically four days of experiments were followed by in-depth interviews with a sample of relevant stakeholders of the village.

The participants were recruited via word of mouth and flyers hung throughout the village inviting participants age 18 years and older to participate. Special effort was made to recruit adults from households engaged in the resource extraction of that village. This had an expected effect of gender bias in favor of males for most of the village sites. Only one member of a family was allowed to participate in the same session. Before the participants receive their payments, they fill out a general survey on their demographics and resource use within the village. The duration of an experimental session was about three hours and the typical earnings of the participants were worth between one and two days of wage labor.

At the end of the series of experiments a handful of people were identified for in-depth interviews. Those individuals were selected among the participants to a sample of the community of resource users that can provide different viewpoints of the social–ecological

Table 2
Social–economic factors.

	Colombia				Thailand			
	Site A/C	Site B/C	Site C/C	Site D/C	Site A/T	Site B/T	Site C/T	Site D/T
Resource use	Fishery	Forestry	Irrigation	None (students)	Fishery	Forestry	Irrigation	None (students)
Age	40.5	47.8	36.3	20.3	44.7	39.1	31.2	19.0
Male	100%	95%	55%	65%	55%	55%	70%	40%
Married	80%	80%	80%	0%	80%	70%	65%	0%
Education[a]	1.7	0.8	1.9	4.3	3.3	3.4	3.7	6
Trust[b]	0.57	0.57	0.48	0.66	0.69	0.63	0.64	0.58

[a] What is the highest grade you have completed in school? 0 None; 1 Some primary school; 3 Primary school; 4 Secondary school; 5 Technical; 6 University.

[b] The trust index is calculated by aggregating six survey questions relating to trust and the community, using a Likert scale (whether in general the person agrees or disagrees with certain statements, assigning 1 point for strongly disagree, 2 points for disagree, 3 points for agree, 4 points for strongly agree, using this formula. (B + C − A − D − E − F + 14) / 18. The statements were the following:

A. Most people in this village are basically honest and can be trusted.
B. People in this village are mostly interested in their own well-being.
C. In this village one has to be alert, or someone will take advantage of you.
D. If I have a problem there is always someone in this village to help you.
E. Most people in this village are willing to help if you need it.
F. If you lose a pig or chicken someone in the village would help look for it or would return it to you.

context. At the end of the week, a session was organized to discuss the experiments.

Each of the forestry games was conducted with 4 groups of 5 people. As a result 20 persons participated in each of the six villages, leading to a total of 120 individuals. In 2008, the experiments were replicated by using the same protocol and incentives with university students in Bogota and Bangkok, with 20 students (4 sessions) in each city.

The experiments were part of a bigger study during which different experiments were performed in each community. At the start of the experiment participants were informed that the experiment did not relate to experiments they may have heard about from village members who have participated before. We will test the possible effect of contagion between sessions in our statistical analysis. A year later the research team returned to the villages and performed additional analysis which we use to interpret the experimental results. We asked original participants to change the game into a design that comes closer to their actual context and perform those role games with a new set of participants. We also discussed the experimental results with the villagers and performed ethnographic analysis (Castillo et al., 2011). During these return visits we derived additional information on the organizational structure, history of the community, and challenges in resource governance. We discuss our statistical insights from the experiments in the context of the qualitative information derived during the return visits in the Discussion section of this paper.

The average age of the villager participants was 39.9 years (Std. Dev 13.8), and 28% of them were females. About two thirds of them reported living in their village for their entire life. Among the student participants the average age was 19.7 years and 50% of them were females. The education level of the villagers varied. 12% of them had no formal education, and about 30% of them with some or complete primary education. Forty-three percent of the players had secondary education and only approximately 16% received technical or university training.

In the experiment, the participants know who else is participating, but they do not know the decisions of the other individuals during each of the 20 rounds that the experiment lasted for each group. Only the aggregate outcomes of the decisions are presented to the group in each round. They are not allowed to communicate with others during the experiment. Assistants were made available during the experiments for those participants who had difficulty with reading and/or arithmetic.

4. Experimental Results

Fig. 3 provides a general overview of the resource size over the rounds. In all communities we see that the average resource size declines rapidly during the first ten rounds. In the first round about 20 out of a maximum of 25 trees is harvested. On average the resource is not completely depleted at the end of 10 rounds. Two communities, the students in Bogota and the irrigation community in Colombia, decline the resource rapidly almost as fast as the Nash prediction. The other communities have a steady decline. After the rules have been elected there is much more variation between the groups.

Fig. 4 shows the average resource size over the rounds, but separating the different elected rules in stage 2 of the experiment. We plot the results for all 32 groups for the first 10 rounds (baseline game) and the second 10 rounds (elected rules implemented). After one of the three rules is implemented (rounds 11–20), the average resource size is sustained over the rounds at a higher level than without the rules, but still below the group optimal strategy and above the Nash prediction.

The average number of trees in the resource during the baseline game and rounds 11–20 is given in Table 3 for the groups within each village. The average stock varies from 25 to 41 in the baseline game, and from 41 to 61 in rounds 11–20, which shows that there is a substantial variation across villages. The forestry villages have the highest stock in rounds 11–20 within in each country, and the student groups the lowest. The average level of the resource is

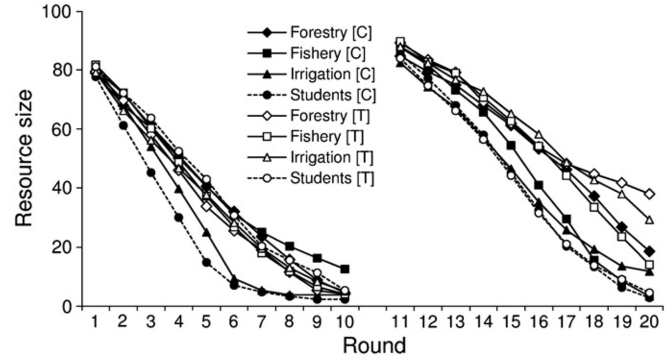

Fig. 3. Average resource size separated for all 8 villages for rounds 1–10 (stage), and rounds 11–20 (stage 2).

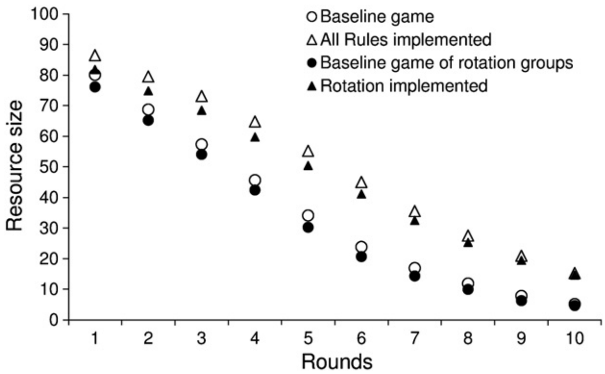

Fig. 4. Average resource size for all 32 groups for rounds 1–10 (baseline game) and rounds 11–20 (all rules implemented). We also added the average for the 19 village groups who have elected the rotation rule for rounds 1–10 (baseline game of rotation groups) and rounds 11–20 (rotation implemented).

35.13 during the first 10 rounds, which significantly ($p < 0.001$) increases to 50.32 trees during the second 10 rounds, using the Wilcoxon Matches-Pairs Signed-Ranks Test. Note that this test, like all following non-parametric tests are at the group level. The average group earnings during the first 10 rounds is 125.34 which drop to 113.28 in the second 10 rounds, after accounting for the penalties paid by those inspected. This difference is significant ($p < 0.001$) using the Wilcoxon Matches-Pairs Signed-Ranks Test. In the first 10 rounds on average 4 trees were standing after 10 rounds, while in the second 10 rounds this was 17 trees.

We also see that there is a high percentage of rule breaking, especially in villages in Colombia. Of those decision situations where persons were not allowed to harvest due to the enforced rules, Columbian villagers harvested between 70% and 83% of the time. Such levels were much lower for the Thailand cases as shown in Table 3. The fishery village in Thailand has the highest level of rule breaking among the Thai cases. However, the levels of rule breaking for students were similar and much lower in both countries.

The group earning varies from 109 to 136 in the baseline game. Hence some groups mimic the Nash equilibrium (115), while others are between the Nash and the cooperative equilibrium (165). In rounds 11–20, group earnings decreased due to the payment of penalties for breaking the rules in addition to the lower number of trees harvested. Some groups lost more than 20 tokens from penalty payments, others leave a high number of trees at the end of the experiment.

During the first 10 rounds, groups from forestry villages, other villages and student groups do *not* have significantly different earnings nor do they have different levels of average resource stock. Using a two-tailed Mann Whitney test the p-values for earnings are 0.120 (forestry groups vs other villages), 0.328 (forestry groups vs student groups) and 0.881 (other villages vs student groups). Thai groups collect more than the Colombian groups (126.7 vs 132.1, with $p = 0.016$) due to more sustainable rates in the first rounds. Since we do various tests on the same data set we should consider a Bonferroni correction. With a significance level of $p = 0.05$ and four tests we need to use a $p = 0.0125$ for a significant difference.

The p-values for the average resource size are 0.528 (forestry vs other villages) 0.328 (forestry vs student groups), 0.238 (other villages vs student groups) and 0.014 (Thai vs Colombian groups). This means that we do not find a significant different effect of the experience of the participants on the way they play the game in contrast to Hypothesis 3. The earnings are significantly higher compared to the Nash equilibrium (p-value < 0.001), in contrast to Hypothesis 1.

We performed a multi-level mixed effect linear regression analysis on the level of extraction (Table 4). As expected, the higher the maximum allowable harvest rate, the higher the actual harvest level. We also find that for the first ten rounds the extraction level is reduced over time, which may indicate some level of learning. The significant effect of the session number indicates that there might be some contagion of people participating in earlier experimental sessions as also found in Travers et al. (2011). No significant effects are found for the level of trust, which country participants came from, their gender, whether they are student or come from a villager of foresters.

Table 4 also shows the statistical results for rounds 11 to 20. We now see that the communities where experiments are performed start making a difference. Forest communities extract less, and student groups extract more than the average groups. The level of trust is found positively related to the level of extraction, and the possible explanation is explored below.

In rounds 11–20 we see differences between the types of groups partly caused by group electing different rules. Compared to the quota rule, lottery rotation and rotation rules extract more, if the participant is allowed to harvest. If participants are not allowed to harvest during a round, we see a similar level of harvest as observed in the groups who use the quota rule.

In order to allow comparison we only look at the village groups who elected the rotation rule. The other rules are not elected sufficiently to include in the analysis (Table 3). We also exclude the student groups which did not elected the rotation rule frequently. This leads to 19 groups. Additional analysis in Appendix A shows that the results are robust in case we include all groups. For the rounds with 25 or more trees the average harvest level drops from

Table 3
Results of experiments.

	Colombia				Thailand			
	Site A/C	Site B/C	Site C/C	Site D/C	Site A/T	Site B/T	Site C/T	Site D/T
Trees Rounds 1–10	41.0	38.3	29.4	24.5	36.7	35.2	36.0	39.6
Trees Rounds 11–20	46.1	55.1	43.3	40.9	55.5	61.0	60.2	40.6
Lottery	1	1	0	0	1	0	1	1
Rotation	3	3	4	2	3	3	3	0
Quota	0	0	0	2	0	1	0	3
Rule breaking	83%	80%	70%	49%	65%	43%	48%	44%

Table 4
A multi-level mixed effect linear regression analysis is performed on the level of extraction from the forest. The independent variables are the maximum allowable harvest levels, the round, trust, the number of the session, and dummy variables for country, gender, forest villager and student participant. For the analysis of rounds 11–20, we included dummy variables on whether harvesting is allowed, and which rule was elected.

	Extraction	Extraction
	Rounds 1–10	Rounds 11–20
Constant	1.630*** (0.219)	−1.367*** (0.437)
Max harvest	0.485*** (0.023)	0.603*** (0.033)
Round	−0.187*** (0.014)	0.018 (0.015)
Trust	−0.088 (0.207)	0.859*** (0.265)
Session	0.019** (0.008)	0.035*** (0.011)
Country (Thailand = 1)	−0.081 (0.115)	−0.191 (0.118)
Gender (Female = 1)	−0.073 (0.069)	−0.046 (0.089)
Forest village	−0.025 (0.138)	−0.231* (0.139)
Student	0.150 (0.139)	0.584*** (0.167)
Not allowed (=1)		−1.756*** (0.085)
Random access		1.436*** (0.167)
Rotation access		1.427*** (0.154)
N	1600	1580
-Log likelihood	2522.362	2879.478
Wald $\chi 2$	2049.63 ($p < 0.001$)	893.68 ($p < 0.001$
χ^2	8.60 ($p = 0.014$)	2.84 ($p = 0.242$)

***p < 0.01, **p < 0.05, *p < 0.1.

3.43 to 2.94 trees which is a significant reduction ($p < 0.001$) using a Wilcoxon Matched-Pairs Signed-Ranks Test. In Fig. 4 we see that the average resource size is very similar for only those 19 groups who elected the rotation rule.

Table 3 shows that the level of rule breaking in rounds 11–20 is high. More than half of the time a person harvested more than allowed. The fraction of rule breaking is high from the first round after the elections onwards until the end of the experiment. This indicates that there is a persistent level of non-compliance independent of the remaining level of the resource.

The degree of rule breaking is especially acute for villagers from Colombia. A multi-level mixed effect logistical regression analysis provides insights what causes individuals to harvest when it is not their turn (Table 5). In Colombia individuals who have more trust in others in the community are more likely to break the rule. There is no contagion of people participating in earlier experimental sessions. Thai participants do break the rules less frequently when they trust others more. Furthermore, we see an increase of rule breaking over the rounds and observe that that there is a correlation between session number and the probability of rule breaking. This last observation indicates that there might be contagion between sessions.

The results in Table 5 are for the 19 villager groups who elected the rotation rule. When we look at all the 32 groups, Table A1 of Appendix A, we find the same results. We also see that students in Bogota break the rules less, which supports the ethnographic analysis (see below) that distrust to outsiders may have led to the higher rule breaking in villages.

Finally, we performed the same analysis of Table 5 for the fishery and irrigation games which were also performed in these villages (see Castillo et al., 2011; Janssen et al., 2012) as shown in Tables A2 and A3 of Appendix A. Although the spatial and temporal structure of the games are very different we find some partial confirmation of the findings for the forestry game also in the other games, especially Colombia.

5. Field Research

What explains the differences in the level of rule breaking between the different communities? Although participants could vote for one of the three proposed rules, these rules were seen as coming from external agencies. In understanding the lack of compliance, we make use of complementary investigations in the villages a year after the experiments were performed. We went back to the villages to give them feedback on the experiments and the results, and proposed to them an opportunity to modify the game to introduce some realism. This was a way to assess what type of context players had in mind when they did the experiments. In each village we crafted a game corresponding to their context (crafting a fishery game in the fishery village (Site A), a forestry game in the forestry village (Site B), and an irrigation game in the irrigation village (Site C)).

Table 5
A multi-level mixed effect logistical regression analysis is performed on whether a participant broke the rule or not. The independent variables are the round (11–20), trust, the resource level at the start of the round and the number of the session.

	Rule breaking (yes = 1)	Rule breaking (yes = 1)
	Colombia	Thailand
Constant	0.101 (2.609)	−1.894 (1.822)
Round	−0.148 (0.119)	0.122 (0.084)
Trust	7.579*** (1.283)	−5.712*** (1.236)
Initial resource	−0.008 (0.012)	0.002 (0.010)
Session	0.037 (0.040)	0.163*** (0.061)
N	285	255
-Log likelihood	120.307	150.742
Wald $\chi2$	36.01 ($p < 0.001$)	29.60 ($p = 0.003$)
χ^2	0.00 ($p = 1.000$)	13.83 ($p = 0.0001$)

***p < 0.01, **p < 0.05, *p < 0.1.

Several lessons from the games are relevant for the interpretation of the *forestry* experiments. In site B in Colombia, villagers are more autonomous in governing their commonly shared territory, given that this village is located in a collectively titled land. They are accustomed to crafting their own local rules. With regard to external rules, villagers see it as acceptable behavior to follow only the local rules. There is no effective social or pecuniary sanction for breaking external rules. The more trust there is among villagers, the less social pressure there is to follow these external rules, and the more confidence to break the rules. This could explain why we find a correlation between the stated inter-personal trust and the level of rule breaking. It may seem that these groups interpreted the rules we implemented in the game, not as theirs, but as externally enforced by an authority. The higher levels of trust could imply, therefore, a license to other group members to break such rules because of their weaker legitimacy.

An interesting phenomena from the field work during the first and second visits are related to the role of the sawmill owners who, with oligopolistic power, purchase the timber extracted by numerous individual loggers such as those who participated in our experiments. The sawmill owners act as poor enforcers in the community. The sawmill owners play the role of the main middleman in the supply chain of timber. Loggers are strongly dependent on sawmills' demand, who in turn, depend on the regional and national timber demand. Through this mechanism the middlemen drive forest extraction and ultimately could be shaping the ecological conditions of the forest. In general their market power makes them price setters, responding to the demand of the next step in the supply chain. These sawmill owners at times will attempt to enforce certain rules about the size of the timber logs, although they are poorly regulated by the market and the authorities, which are mostly absent in the region. We did not find that these middlemen had any interest or impact in creating incentives for a more sustainable rate of extraction of these forests.

In the Colombian site C the local aqueduct has been built and managed endogenously as are many others in the rural areas of this country. Villagers self-organized to obtain resources and construct the aqueduct as a consequence of a severe drought 20 years ago. The implication of this situation combined with the historical and cultural characteristics of the inhabitants of this region have produced a particular behavioral relation with external institutions. Usually there is a gap between behavior and discourse, and also low levels of trust among the community, and even lower toward external actors. Interviewees and participants in the role playing game talked often about the selfishness of this community and also how the rules in the experiments were seen as externally imposed, even if players were asked to vote for the rule to be applied in the experiment. Rule compliance is a function of its legitimacy, which in turn is built endogenously based on the efforts of the community.

The high level of rule breaking in the Colombian site A (83%) could be related to two factors: rule legitimacy and household needs satisfaction. The context analysis showed the relevance of the participation of locals in the construction of rules, especially regarding the National Park authorities, which, in this case, regulated the fisheries in the conservation area. When environmental authorities do not consult fishermen about rules, this renders the legitimacy of these rules low and in turn increases the level of rule breaking. On the other hand, the rule game provided some clues on the high weight local fishermen give to the fulfillment of household needs. The breaking of formal rules is usually justified by convenience or necessity.

In *Thailand* there was one village which had much higher rule breaking rate than other Thai groups, namely site A. The village members are very individualistic in sharing the resource (Castillo et al., 2011). Each one will harvest the maximum because they have in mind that their neighbor will take the maximum and will not leave anything for them. They are very resistant to public regulation and do not trust the government rules. This may explain why they are the ones who break the rules in the forestry experiment (Table 3). Surprisingly, they have a higher trust index, but they may trust other fellow villagers to not socially sanction them for breaking the external rules.

On the other hand, sites B and C experienced low levels of rule breaking. In site B, villagers acted in the past as employees of a logging company, but did not exploit the forest by themselves. Presently, cutting trees is prohibited in the forest and this rule is followed. This is a national rule which is respected by all farmers in Thailand. The consequence is that the experiment is not really about the trees but about the renewable resources they exploit in the forest. In the forestry village they considered that the experiment is similar to the harvest of bamboo trees.

In reality there is not really a scarcity of the resource: bamboos are highly renewable and not over-harvested. Like in Colombia, the harvesting of the bamboo is driven by a trader demand which not exceeding the bamboo natural production. This may explain why, when the players living in a forestry village do the experiments, they do not all behave as selfish rational actors. In the redesign of the experiment, the villagers talked about a sanction in case someone takes more than the allowed quantity.

In site C rule breaking was not as high as site A but it was similar to site B. The farmer's irrigation system is provided by the government, and they can extract as much as they want in their actual irrigation system. Furthermore, farmers share water with their neighbors. During the return visit we learned that farmers negotiate with local government agencies on irrigation management.

In both countries the student groups did not have high rule breaking rates. A possible explanation is that the rules proposed by the experimenters are not seen as externally imposed rules. Furthermore, the students have not had the same experience with external regulations on resource use and may not express dissent based on past experiences. All in all, the information from the return visits teach us that the behavior of the players is very much context dependent. It depends on the history of the social group, the relationship they have with a given resource, the relationship among members of the group and with the external forces such as external regulations.

6. Discussion

In this paper we reported on field experiments on forestry resources in Colombia and Thailand. In most groups the common resource was depleted by or before the end of the ten rounds, but not as rapidly as the model of a self-oriented and income maximizing model would suggest. Hence Hypothesis 1 is rejected. We did not find a statistical difference in the resource use experience of participants for rounds 1–10, which does not support Hypothesis 3.

In the second set of ten rounds, after participants voted for one of three possible rules (lottery, rotation, quota), groups harvested less from the common resource. This confirms Hypothesis 2, but a high frequency of rule breaking was observed with a probability of monitoring equal to 1/6. This was especially the case for villagers in Colombia, who broke the rules when they had higher levels of trust in other community members, which might seem contrary to intuition. However, together with the information collected during the return trips where interviews and role games were conducted, this apparent contradiction indicates that these villagers saw the elected rules as externally imposed regulations which are socially acceptable to be ignored within the community. We find that students, foresters and villagers who do not extract from forest make different decisions in rounds 11–20, which is support for Hypothesis 3. We do not find evidence that higher levels of trust in other community members reduce the level of harvesting. In fact, we find that opposite in some villages, which is in contrast to Hypothesis 4.

The results for rounds 11–20 teach us that the question of the relation between trust and rule-compliance, which is considered as a fundamental one in the field of CPR (Ostrom, 1990), should be carefully investigated. After the experiments and the associated investigations it is clear that trust in other people in the community does not necessary correlate with observed behavior in the game. It might be important in future field experiments to measure trust in people from different groups (including those outside the community) in order to understand the responses to interventions. We may even consider that a trustful group will trust that the members of the group will not follow a given set of rules on resource management, especially if these rules are imposed.

In the villages of this project two extremes can be distinguished depending on the aversion on external rules and the specific trust they have on others. In the first one, villagers may have strong objections to external regulations and do not follow them in real life and trust other villagers to do the same. At the opposite, people do not have a strong adverse reaction to external regulation and follow the elected rules because there is a general and specific trust that others will also follow the rules.

Our results on the high levels of rule breaking do not suggest an example of crowding-out of cooperative behavior, though. Instead, the data suggest that a fraction of individuals were not interested in complying with the rule from the beginning and decided to face the stochastic enforcement mechanism. Other studies using similar common-pool resource experiments with imperfect monitoring have also shown steady levels of non-compliance over time (Cardenas, 2004; Rodríguez-Sickert et al., 2008), although these comparisons must be made with caution as our experiments has also a dynamic stock process that was not included in the other studies.

The outcomes of the experiments show the importance of the social context of the community of resource appropriators (Poteete et al., 2010) and how social norms interact with externally imposed regulations (Cardenas, 2001). Particular conditions of the resource users and their institutional contexts may explain, as discussed before, the differences between the two countries. However, experience with specific resource management and specific regulations do not lead to differences in the decisions, but expectations about other community members and outsiders do. This shows the importance of how regulations are implemented and how their effectiveness is the result of interactions between social norms and rule enforcement, sometimes acting as complements, other times as substitutes. Thanks to the additional work conducted in the field with interviews, surveys, and role games we believe that the greater context, beyond the particular individual, the particular session, and even the village, might be playing an important role in how the rules we tested in the experiment were interpreted. Different interpretations may have emerged out of the two contexts due to much more general social norms about the role of rules to guide the normative behavior of individuals. When the experiments were conducted in 2007, Thailand ranked 84th in the world tables for corruption perception index, twenty places better than Colombia (Transparency International, 2012). Using the World Values Survey (Colombia 2005 and Thailand 2007) online databases (http://www.wvsevsdb.com/) one can find that Colombian people are more likely to agree with the sentence “Competition is good” and more Thai people agree with “Competition is harmful.” Likewise, Thai people align more with the sentence “People should take more responsibility” and Colombians leaning more toward “The government should take more responsibility.” To the question on how much respondents are confident in the civil service or the justice system, one can find that many more Thai respond positively than the Colombians. In terms of trust, one can find a clear difference between the two societies, with more Thais trusting their neighborhoods, trusting people they meet for the first time and most people in general.[1]

Nations and societies build norms that interact with regulations. Other experimental studies using cross-country samples have also found how national based norms may explain behavior. For instance Herrmann et al. (2008) find, using 16 comparable subject pools in different countries, that the national levels of civic norms and rule of law explains individuals' willingness to punish behavior by others that goes against the group benefit. How individuals interpret and evaluate the costs and benefits of complying or violating rules should be analyzed through the lens of social norms. Our experimental design had the same material conditions for the two samples of villagers in terms of the benefits of leaving resource units in the ground for future use and the benefits of extracting them, as well as the same material implications of imposing the different rules offered to the participants. Yet, we find differences across the two samples, which might be consistent with the field observation and other national secondary data regarding the social norms that also govern behavior and rule compliance.

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Appendix A. Supplementary Data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2013.03.012.

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[1] In other questions on trusting the government, from the same World Values Survey the results were mixed.