Chapter 8

Should the State regulate the Local Commons? Lessons from Economic Experiments in the Field

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Strategies that integrate conservation and development are especially critical in regions where ecosystems provide direct and indirect benefits for local users and others, and where because of institutional conditions there is a commons dilemma. State intervention is sometimes thought necessary and desirable to correct the externalities arising from the conflict between short-term needs to extract a resource from the common-pool and the long-term need for preserving the ecosystem for its renewability and its capacity to provide other indirect ecological services.

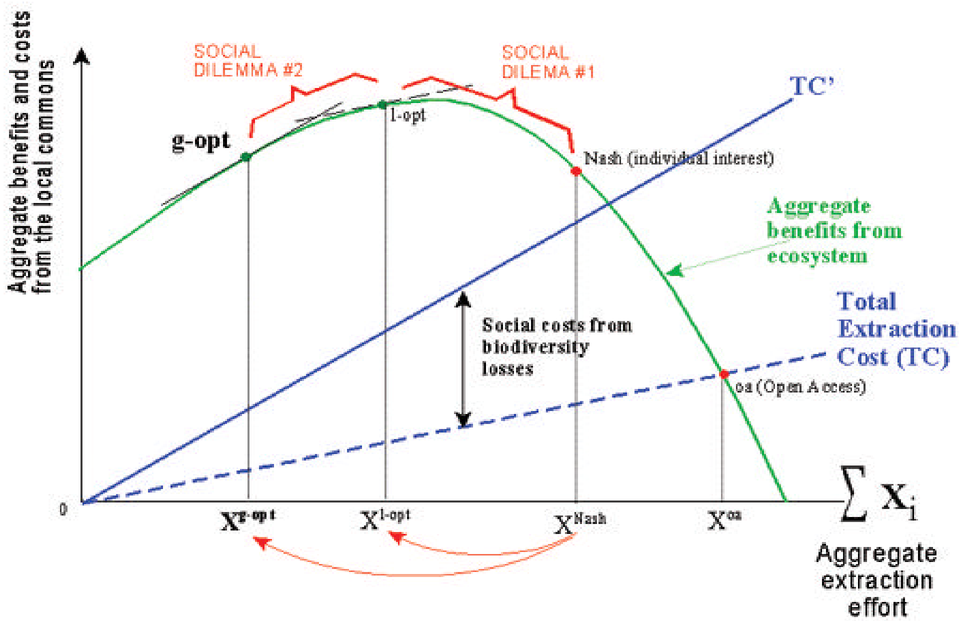
In this paper we question the assumption that state intervention will always improve what a group of users may achieve through self-governing institutions— even when users do not coordinate their individual actions. State intervention, we will argue, may also generate other unexpected changes in human behavior that may work against the goals of balancing conservation and development, and eventually do more harm than good. Through an analysis of economic experiments in three villages of Colombia we explore such arguments and derive some results that can contribute to the challenge of designing better policies and institutions for the effective management of ecosystems. Further, the results will provide grounds for an emerging literature on the possibilities of conservation through community institutions and mitigation of the so-called 'tragedy of the commons' (Hardin 1968). Combined, these two results, on social losses due to state regulation, and the potential of community management, may be important for the design of policies in regions like Latin America where states have been unsuccessful in enforcing conservation mechanisms in protected areas and where traditional community mechanisms and organizations still exist for coordinating social relations in many rural settings.

The problem of the local commons

Regardless of existing *de jure* property rights, many ecologically rich areas in developing countries suffer from the two basic conditions, non-excludability and subtractibility, that distinguish common-pool resources from those which are private or purely public goods (Ostrom 1998). These conditions impose serious difficulties in designing a policy that achieves social efficiency. Non-excludability makes it is very difficult or costly to exclude users from extracting or benefiting from the goods and services provided by the ecosystem. But as in private goods markets, subtractibility implies that a unit extracted from the commons and used by an individual is no longer available for use by others. Furthermore, if too many units are extracted, the resource's natural capacity to renew itself is affected. These problems are similar in private and state owned areas where weak enforcement of the property rights allows for levels of occupation and extraction of resources, whether by the rural poor or commercial loggers.

These conditions, along with the ecological features of many ecosystems, create the situation illustrated in figure 8.1. The horizontal axis represents the level of aggregate extraction of a resource (e.g., logging) by a group or a community. The vertical axis represents the costs and benefits derived from the use and non-use values of the ecosystem that produces the resource (e.g., logging values, water regulation, biodiversity preservation, erosion control). From a social standpoint we obtain the best result by maximizing the difference between total benefits and total extraction costs. Benefits include the non-market services provided by the natural environment and, therefore, the positive value for the aggregate benefits at a zero extraction level. The concavity of the total benefits function emerges from the nature of most renewable resources and fragile ecosystems in which the ability to renew and to provide other services is reduced, as the volume of biomass extracted goes beyond its maximum sustainable yield. As for extraction costs, for the sake of simplicity, we can assume that these remain constant for each additional unit of extraction and therefore can be depicted by the line TC. Clearly we maximize the net social gains at the l-opt point, achieved at a total extraction level of $X^{l\text{-}opt}$.

Figure 8.1: Two dilemmas of local commons with global benefits.



However, the resource might not be extracted at this optimal ($X^{l\text{-}opt}$) level. It is difficult to exclude users from extracting one more unit of the resource since, from the standpoint of each of them, this is rational behavior given that the average gain from one unit is still greater than the average cost of extraction. If all users acted on their self-interest, the sum of their actions would drive aggregate extraction to much higher levels, and aggregate benefits to much lower levels. The result would be the predicted "tragedy of the commons" (Hardin 1968) represented by the (oa) point for open access equilibrium. This prediction has been called into question by game theorists such as Cornes and Sandler (1983) who consider the possibility of strategic behavior by community members, that is, where agents form conjectures about the behavior of other commons users. These models basically predict that for many cases of non-coordinated actions by users, their behavior would still create a socially inefficient level of extraction somewhere between the socially optimal and the open access prediction. We label this point "ñash' in the graph, using game theory jargon; this simply refers to the results of each player maximizing individual payoffs based on their conjecture of what the others will do.

The problem of common-pool resources that provide global benefits

In a further step we can include in the problem the issue of external benefits from conservation in the form of biodiversity benefits lost as aggregate extraction increases. This refers to benefits foregone by other individuals who may benefit from conservation of this ecosystem though they live outside the community. In the model we can include these by adding an additional portion of costs as extraction increases, shifting the TC curve to TC' in the graph. This additional problem transforms our original benchmarks from l-opt to g-opt and therefore calls for a lower level of aggregate extraction effort $X^{g\text{-}opt,}$ where social welfare would be maximized. We now have two dilemmas to solve. One is a local dilemma where the individual interests of users may conflict with the outcome that will affect the group, and a second dilemma that is global in character, in which the needs and interests of the community will be in conflict with the needs of the rest of society. In a sense, these two dilemmas synthesize the challenge of conservation and development, the focus of this conference.

The challenge is a question of creating a new set of rules that induce individual users to change their behavior so that in aggregate it results in values closer to $X^{g\text{-}opt}$. For that to occur, we need first to solve the local dilemma, i.e. getting to $X^{l\text{-}opt}$. One of the most 'popular' ways of dealing with such dilemmas in the public policy and conservation literature is to have the state intervene by constraining behavior in some way. The usual argument for such intervention is that, due to the lack of individually assigned property rights to the resource, the tragedy of the commons is the most likely outcome. Restricting the number of users and the individual quota of resource extracted has been a conventional approach, albeit a costly one to monitor and enforce. Similar problems accompany restrictions on resource extraction technology. Imposing Pigouvian taxes or applying subsidies that correct the externality may also achieve improvements in social efficiency.

A field experiment

Based on the expanding field of experimental economics and inspired by the existing literature on public goods and common-pool resources experiments (Ledyard, 1995; Ostrom, Gardner and Walker, 1994), we designed a simple experiment and brought it to the field in the summer of 1998 to learn from the behavior of actual users of common-pool resources. Our experiment is a simple decision-making exercise involving groups of eight participants who make economic decisions that have clear economic incentives (in kind and cash) and involve the kind of externalities discussed above. We performed the experiment between June and August of 1998, with about two hundred residents from three villages in Colombia.

In the village of Encino, located in the eastern Andean region, residents extract firewood, log timber on a small scale, and hunt in local tropical cloud forests. Like all of the sites we visited, water for consumption and irrigation comes virtually untreated from nearby rivers. Of the three areas that we visited, the relationship between forest cover and water quality is most critical in Encino, and the residents of this village are acutely aware of the problem. Though water quality degradation caused by forest cover loss is less severe in the villages of Circasia and Filandia in the Quindio coffee region in the mid-Andes, it remains a significant problem. In Quindio, subjects for our experiments were drawn from a group of families whose livelihood is related to the extraction and processing of natural fibers from local forests. As in Encino, water is drawn from local rivers and residents are aware that extracting forest products can lead to lower water quality. In Nuqui, located on the Pacific coast, villagers harvest coastal mangroves for firewood and other wood and food products, but their water comes from further inland; hence, they do not experience a direct link between exploitation of local wood sources and water quality. However, they face a similar dilemma because exploitation of the mangroves for wood adversely affects coastal fish populations upon which they also depend.

In short, the population is made up of rural households whose members depend heavily on local forests for wood products. In each location, exploitation of local forests affects another aspect of their livelihoods adversely: water quality in Encino and Quindio, and fish populations in Nuqui. Hence, the subjects face social dilemmas in their daily lives similar to the dilemma present in the experiments. In each of the three settings, the participants generally knew each other well, having lived in the same village for most of their lives. Schooling, age and income levels varied significantly among participants in each group. Most had fewer than 6 years of schooling, roughly half were between 30 and 50 years old, and all were 16 or older.

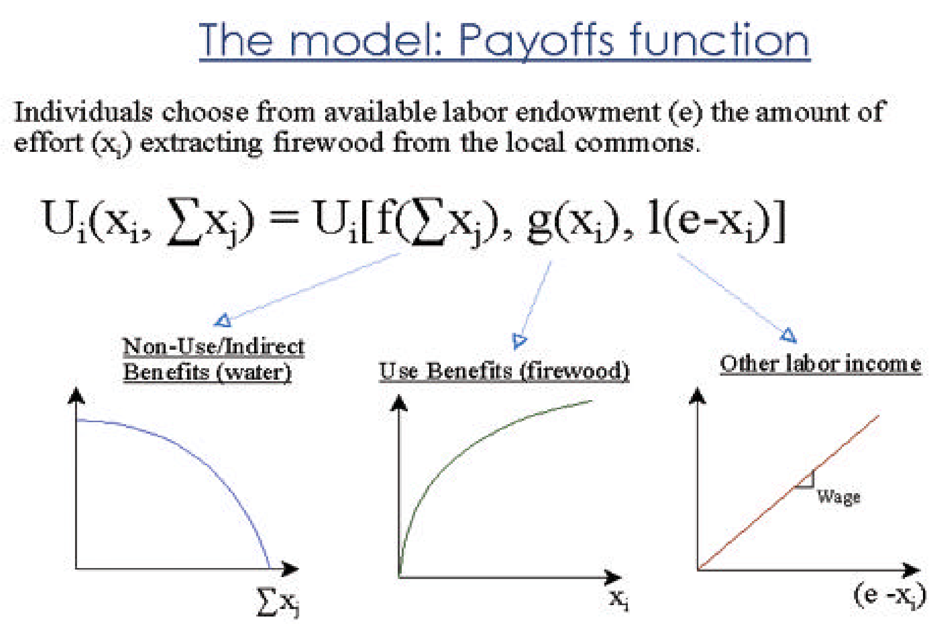
Studying institutions and human behavior through experiments

We are interested in examining the effects of external institutions (rules and regulations imposed from outside a group) on behavior in an experimental setting, in particular the effects of external control of local environmental quality. We designed our experiment to approximate the common-pool resource dilemmas that rural villagers in developing countries are likely to face.

Specifically, subjects were asked to decide how much time they would spend collecting firewood from a surrounding forest, realizing that this activity has an adverse effect on local water quality because it leads to soil erosion.

Each individual's decision generates points translated into cash earnings; the number of points depends on the individual's decision as well as the aggregate decision of other members of the group. The payoffs for our experiments were determined by a simple model of a fixed number of homogenous individuals exploiting a local forest for firewood. In each round of the game, players are given an endowment of time (8 months) that can be allocated to collecting firewood or to providing labor to an unrelated market. The payoffs earned by an individual are therefore the sum of three components, shown on the following three graphs in Figure 8.2. The first component is individual benefits due to conservation of the commons; these decrease as the group extracts more of the resource. The second component is individual gain from extracting the resource. The third is the amount of effort (labor) not allocated to the commons; this generates income for the individual[1].

Figure 8.2 Components of Income for Local Commons Users



Notice how the group externality is generated. The self interest driving extraction by individuals (the second component) conflicts with the first component, which depends on what the others do. To determine payoffs, we created the basic source of information that participants had to use when making decisions -the payoffs table shown in Table 8.1, which includes both individual choices (columns) and the choices of all other participants (rows). The values in the cells are Colombian pesos earned by each player in each round of the game. Participants played about 18 rounds each. At the time of the field exercises the exchange rate was around USD 1,350 pesos/dollar. The values in the table were generated through the payoffs function described above in Figure 8.2, for the purpose of differentiating clearly what the social optimal and the Nash solutions should be in the experiment according to the general common pool resource model described in Figure 8.1.

The payoff table 8.1 shows the benchmarks discussed in the following way. The shaded cells (which were not shaded in the tables provided to participants) indicate what we call the Nash strategy, that is, what each player should choose if only payoffs were driving a player's decision, with no thought to the effects of their choice on others. Suppose, for example, that there are eight players and, on average seven choose to spend three months collecting firewood from the surrounding forest. Since the sum of the seven players' choices is 21 months, Table 8.1 indicates that the eighth player's payoff-maximizing response – the individual's best- Nash response – is to spend eight months collecting firewood. This choice is based purely on self-interest, without regard for the welfare of the others in the group. Note that player eight's payoff in this outcome is 630 points, while other seven receive 453 points each [for each of them, the sum of the others' choices is 26 months, when they choose 3 months].

Now imagine that the eighth player chooses 3 months instead of 8, while the other seven players continue to choose 3 months. We consider this to be a significantly more group-oriented choice – it is costly because that player's payoff is now 544 points instead of 630: however, each of the other players' payoffs increase from 453 points to 544 [for each of them, the sum of the others' choices is now 21 months, when they choose 3 months].

It is easy to show that in our exercise for maximizing the groups' gains the optimal amount of time each individual should spend collecting firewood is 1 month, yielding 645 points to each player. 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. Notice that if all seven players choose 6 months, it would be unwise for the eighth player to choose 7 or 8 months. It is worth noting that at the Nash equilibrium, subjects earn USD 155, only about 24 percent of the payoffs attainable in the efficient outcome. Our statistical analysis will focus on how the distribution of decisions by players will be around these two benchmarks, and how this affects group and individual earnings.

External Regulation vs. Group Communication as Governing Institutions

Given that pure self interest, with no coordination of choices by players, yields an inefficient outcome, with each player earning 155 points by choosing 6 months in the forest, for a group total of 1240 points, any new rule that aims at reducing the sum of months in the forest should improve social efficiency towards the desirable point where the group's earnings equal 5,160 points when each player chooses 1 month.

We consider two treatments to examine the effects of institutions on changing users' behavior. Each group of eight subjects plays a number of initial rounds of the game without regulation and without communicating with each other. A subset of groups which we label (REG), goes on to play additional rounds in which players are confronted with a government-imposed regulation and sanction that, theoretically, will induce more efficient behavior. The other groups also play additional rounds, but instead of facing an external regulation, individuals are allowed to communicate with others in their group between rounds. We label these groups (COM).

One form of external regulation introduced involved the possibility of an audit. Players found in non-compliance with socially efficient rule X=1 would see their gains reduced in an amount proportional to the excess of extraction above the rule. Specifically, in each round participants faced a 1/16 probability of an audit and the penalty imposed was 100 points for each month in the forest above the 1 month rule imposed by the external regulation. This enforcement regime is rather weak in that the expected marginal penalty is not sufficient to induce risk-neutral players to comply with the quota. We chose a relatively weak enforcement protocol because we believe that weak enforcement best characterizes the state-imposed regulations our subjects actually encounter. In rural communities of developing countries, like those where our experiments were conducted, monitoring and enforcement of local and national regulations is likely to be lax because of high monitoring costs and limited budgets. Since the expected penalty is an additional cost of collecting firewood, individuals should choose to spend less time collecting firewood than they would in the absence of any regulation. Given the payoffs and the expected penalty, players should choose fewer months in the forest.

For another set of participants, we did not introduce the external regulation; instead, we allowed them 3 to 5 minutes of conversation before each decision round. We allowed some groups to communicate because self-governance institutions have historically persisted alongside, or as an alternative to, external regulation in developing countries. In addition, relatively more is known about the role of face-to-face communication in enhancing levels of cooperation in experiments of this general type as reported by Ledyard (1995), Ostrom, Walker and Gardner (1992) and Ostrom, Gardner and Walker (1994).

At the end of each session, total points for each individual were calculated. Subjects were paid that number in pesos for their participation. For the villages in which the experiments were conducted, the daily minimum wage was around 7,000 pesos (about USD 5.20 at the time). Including practice rounds, most participants engaged in 20 rounds of decisions. If all subjects made the efficient choice in each round, they would have each earned about 12,900 pesos (approximately USD 9.55) in the experiment. Average earnings for the experiments was 7,884 pesos which, as planned and announced, was intended to compensate for the opportunity cost of time devoted to participating in the study.

Experimental results

Consistent with findings in the experimental literature on contributions to public goods and exploitation of commons [Ledyard (1995), Ostrom (1998)], we find that when subjects do not face external restrictions and cannot communicate with each other, their decisions tend to be neither pure Nash strategies nor efficient choices, but somewhere between these extremes. Absent regulation, the simple ability to communicate allows individuals to make more efficient choices. However, our results about the effects of external regulation are new, regulatory control caused subjects to tend, on average, to make choices that were closer to a more self-oriented behavior, and further from a socially efficient outcome, than when individuals made unregulated decisions without communication. Consequently, average individual payoffs in regulated situations were lower than in the absence of regulation, in spite of the fact that the regulatory institution was designed to induce more efficient choices and much lower than the payoffs of those subjects who were allowed to communicate with each other.

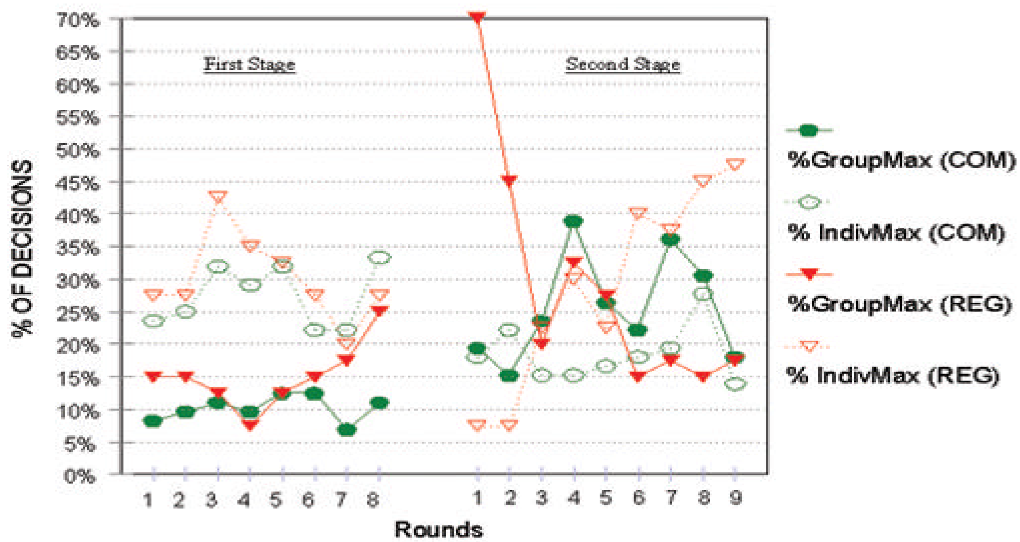
Group vs. individual maximization strategies

We have mentioned before the two benchmark points from Table 8.1 for the analysis of the results. In the first of these, the group maximizes payoffs when each individual chooses "1 month in the forest," yielding 645 points. We call this the GroupMax strategy. The other strategy of interest is when an individual maximizes her own payoffs on the basis of what others do, which we call IndivMax; it is indicated by the individual's months along the shaded cells in Table 8.1. As the learning process continues in two stages, players choose the time they will spend in the forest. In the case of players facing the regulation, the expected cost of the penalty should induce players to shift their Nash best response to the left at least one month.

We will use two concepts described, IndivMax and GroupMax, to study the effects of the two types of institutions presented (REG and COM) on individual behavior. Consistent with most experimental behavior from social psychology and economic studies, in situations involving a group externality, individual behavior within groups varies along a range of possible choices. Some players make their decisions closer to the social optimum and others closer to the individual maximization strategy. Depending on the number of choices closer to either benchmark, the group's outcome will vary. We concentrate here on those players who attempt strategies close to the IndivMax and GroupMax described, under the assumption that they are more clearly reflecting individualistic and cooperative behavior, respectively. As the number of players who choose months closer to the GroupMax increases, group earnings should increase and the forest be better conserved. On the other hand if more players make choices closer to the shaded cell benchmarks, group earnings decrease, i.e. the commons is over-exploited.

To perform an analysis[2] of the data we estimate the percentage of decisions in each round within 1 month of the social optimal solution (i.e. when players chose between 0 and 2 months), and the percentage of decisions within 1 month of the Nash strategy (i.e. when players chose a number of months within one column to either side of the shaded cells). With these measures we can analyze the fraction of population in each group displaying individualistic behavior and the fraction cooperating. Figure 8.3 provides a summary of the experimental results analyzed below.

Figure 8.3 Fractions of IndivMax and GroupMax decisions per round



During the first stage of the experiment (rounds 1 to 8) we do not expect differences between the COM and REG groups as they face the exact same rules and economic incentives and do not know the new rule they will face. Such result can be observed in Figure 8.3, where the %IndivMax oscillates around less than 30 percent and the %GroupMax at lower ranges less than 15 percent[3]. The remaining fraction of players makes choices that cannot definitely be classified as either individualistic or group oriented. The effect of this behavior is that on average the COM and REG players were earning respectively USD 370 and USD 377 per round at the end of the first stage, a statistically insignificant difference.

When the new rule (communication or regulation) is introduced in each group, we expect differences in behavior since the new "institutions" introduce new incentives and information to the players. Players in REG groups now face an expected cost if they are inspected and found in non-compliance with the behavior that produces the social optimal result. On the other hand, those permitted face-to-face communication, although not allowed to impose through discussion any transfers of points during or after the experiment, still might use the discussion to introduce other kinds of non-material incentives that groups adopt to induce changes in behavior.

Using the same indices of percentage of players using the IndivMax and GroupMax strategies, we can analyze the effects of these institutions. Let us start with the COM groups, represented by circles (filled and empty) in Figure 8.3. Notice how the group discussion achieves a dual positive effect on social efficiency by reducing the fraction of IndivMax players to under 20 percent, and by increasing the %GroupMax to levels around 25 percent, and in some rounds above 35 percent, including rounds 4 and 7. This change in behavior induced a positive and significant change for COM players who saw their earnings go from an average of USD 377/round during the first stage to an average of USD 471/round during the second stage, a 25 percent net increase.

The institution of external regulation, however, had a more surprising and interesting effect on individual behavior. When the new rule is introduced, a large fraction of players complies with the 1 month regulation, i.e. a high GroupMax percentage (70 percent in round 1 of the second stage), while a much smaller fraction of players choose the IndivMax strategy (around 8 percent in round 1, second stage). The effectiveness of the new rule, which increased earnings dramatically in the first round of the second stage, diminishes after just a few rounds. As players feel more comfortable with the probability of being inspected (1/16 in each round), and given the incentives to choose more months in the forest while others comply with the rule[4], players who were choosing the GroupMax begin to switch to more individualistic behavior which can be seen by the increasing %IndivMax(REG) from less than 10 percent up to almost 50 percent by the end of the second stage. The %GroupMax(REG), meanwhile, decreases from 70 percent to 15 percent. Again, a dual but negative effect on behavior creates an overall decrease in social efficiency which results in much lower earnings for REG players at the end of the second stage, an average of USD366/round for the last 3 rounds. We performed statistical parametric and non-parametric tests for these comparisons across both stages and across treatments (COM, REG); the results support the analysis presented here (See Cardenas 2000). in addition, given that the selection of the buffer zone (one month around the Nash and social optimal benchmarks) for the IndivMax and GroupMax choices could be seen as ad-hoc, we estimated the same fractions for buffer zones of 2 months, yielding very similar results, namely, a decrease in the fraction of cooperators and an increase in the fraction of individualistic choices with the regulation, and an increase in cooperative behavior with communication.

We can thus see how the effect of regulation at the end of the second stage disappears after a few rounds. The fraction of group-oriented choices was back to the level reached before the introduction of the rule; what's more, the fraction of individually oriented choices increased considerably, a phenomenon we attribute to the new institution. In the meantime, the self-governing institution, with individuals discussing during each round, not only improved social efficiency but that efficiency was sustained over time. Notice that while the groups allowed to communicate were never told what the social optimal solution (1 month) was, this had to be explicitly explained to the REG groups when the rule was introduced. The mechanisms through which communication induces more cooperative behavior has been analyzed in the social psychology and experimental economics literature with different behavioral explanations. In very general terms, what we observe in our experiments, in the video and audio tapes of the group discussion, is that the discussions allowed these groups to reinforce the negative consequences to the group of choosing the IndivMax strategy; this included assigning negative labels to players attempting such behavior and, in some cases, identifying who seemed to be imposing negative externalities on the group. Recall that the participants are members of the same village and have know each other for significant periods of time. On the positive side, the discussions focused on the reinforcement of individual and group gains resulting from GroupMax behavior.

Ostrom, Walker and Gardner (1992) discuss and test assumptions from the Hobbesian world according to which covenants without the sword will not lead to changed behavior which enhances the common good. With a similar experimental design, they found in the laboratory with college students what we later found in the field lab regarding the power of communication. In our design nothing could be better for a player than to agree publicly to only a few months in the forest and then choose 8 months, expecting others to stick to the number agreed upon (See Table 8.1). Yet group results improved with non-binding communication. It was under the regulation institution that we observed the individualistic rationale predicted by "cheap talk" and "tragedy of the commons" arguments. With each new round, the best strategy for each player was to choose more months in the forest, expecting the others to follow the externally imposed rule; given the low probability of getting caught, most individuals in each of the 5 groups followed this socially inefficient path.

Final discussion

Many areas rich in natural resources are located where, on the one hand, the State has a weak presence and limited capabilities to enforce formal rules to protect ecosystems that provide goods and services to local communities and beyond. Fiscal constraints by governments, and political and social conflicts associated with frontier agriculture and migration combine to make the state solution a difficult one to enforce. Many of these ecosystems are used by rural communities that have traditionally constructed their own informal institutions for governing individualistically oriented behavior that may harm the common good. Examples of community participation and self-governance in several other sectors of rural life have been well documented under different labels such as social capital (31994), collective action in the case of India (Wade 1988), and self-governance of common-pool resources (Ostrom 1998). In Colombia, a recent study indicates that the decentralization process has led to greater efficiency and equity in the production and provision of public services to rural areas where newly elected mayors have found an environment of community participation through different forms of cooperation and collective action (World Bank 1995).

Also consistent with other areas of research are our findings on the negative effects of external regulation. Bruno Frey recently compiled a body of empirical evidence (Frey and Jegen 1999) on his 'crowding-out' proposition, according to which material incentives aimed at changing behavior towards socially efficient outcomes may in fact 'crowd-out' the implicit incentives individuals may have inherited (Frey 1997, Frey and Oberholzer-Gee 1997, Weck-Hannemann and Frey 1995, Cardenas et al 2000). Documentation also exists for the failure of state imposed formal rules for protecting natural resources. Lutz and Caldecott (1996) discuss the failure of central governments in managing biodiversity conservation and the trends towards decentralized systems. In a series of case studies from experiences in 10 countries worldwide, they show how the involvement of communities becomes a key issue in making governance of biodiversity conservation feasible and effective, and compatible with development. Recent experimental testing of the negative effects of external regulation of the commons provides similar results (Ostmann, 1998; Ostmann, Wojtyaniak and Beckenkamp, 1999; Cason and Kahn, 1999)

Our field work and experimental designs were aimed at exploring these two types of institutions (community and state) for governing social dilemmas involving common-pool resource and the compatibility of individual and social objectives in light of the institution present. Some lessons can be derived from our results, along with the new developments in the literature about human behavior in collective action situations. And the key points presented below should be considered in the design of policies aimed at balancing conservation and development in areas where natural resources are affected by the local commons dilemma. Individuals do not behave according to pure free-riding behavior. Instead, they willing to cooperate in a collective action situation. Therefore, the 'tragedy of the commons' should not be used as a starting point for designing a policy to improve the management of such resources.

- Given that individuals may have group-oriented as well as self-oriented preferences, all institutional designs must consider effects on both. Therefore, a state intervention should be analyzed with respect to the negative effects it may have in 'crowding-out' possibilities for group-oriented behavior[5].
- The potential of self-governing institutions must not be underestimated. Policy designers should recognize the capacity of groups to organize, and provide the legal environment for groups to overcome collective action dilemmas through different types of mutual monitoring and non-material incentives well-known in the field setting, documented by social scientists but usually ignored in conventional top-down policy design.

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Table 8.1: Payoff Table Used for the Experimental Design.

THEIR MONTHS IN THE FOREST	MY MONTHS IN THE FOREST 0	1	2	3	4	5	6	7	8	
0	619	670	719	767	813	856	896	933	967	0
1	619	669	717	764	809	851	890	926	959	1
2	617	667	714	760	804	845	883	918	950	2
3	615	664	711	756	798	838	875	909	940	3
4	613	660	706	750	792	831	867	900	929	4
5	609	656	701	744	784	822	857	889	917	5
6	605	651	695	737	776	813	847	877	905	6
7	600	645	688	729	767	803	836	865	891	7
8	595	638	680	720	757	792	824	852	877	8
9	588	631	672	711	747	780	811	838	862	9
10	581	623	663	700	735	768	797	823	846	10
11	573	614	653	689	723	755	783	808	830	11
12	565	605	642	678	711	741	768	792	813	12
13	556	594	631	665	697	726	752	775	795	13
14	546	583	619	652	683	711	736	758	776	14
15	536	572	606	638	668	695	719	739	757	15
16	525	560	593	624	653	678	701	721	737	16
17	513	547	579	609	636	661	683	701	717	17
18	501	534	565	594	620	643	664	681	696	18
19	488	520	550	578	603	625	645	661	674	19
20	475	506	535	561	585	606	625	640	653	20
21	461	491	519	544	567	587	605	619	630	21
22	447	476	502	527	548	567	584	597	608	22
23	433	460	485	509	529	547	563	575	585	23
24	418	444	468	490	510	527	541	553	561	24
25	402	428	451	472	490	506	520	530	538	25
26	387	411	433	453	470	485	498	507	514	26
27	371	394	415	434	450	464	476	484	490	27
28	355	377	396	414	430	443	453	461	466	28
29	338	359	378	395	409	421	431	438	442	29
30	322	341	359	375	389	400	409	415	418	30
31	305	324	341	355	368	378	386	392	394	31
32	288	306	322	336	347	357	364	368	371	32
33	272	288	303	316	327	335	341	345	347	33
34	255	270	284	296	306	314	319	323	324	34
35	238	253	266	277	286	293	297	300	300	35
36	221	235	247	257	265	272	276	278	278	36
37	205	218	229	238	245	251	254	256	255	37
38	189	200	211	219	226	231	233	234	233	38
39	173	184	193	201	206	211	213	213	212	39
40	157	167	175	182	188	191	193	193	191	40
41	142	151	159	165	169	172	174	173	171	41
42	127	135	142	148	152	154	155	154	152	42
43	113	120	126	131	134	136	137	136	133	43
44	99	106	111	115	118	119	119	118	115	44
45	86	92	96	100	102	103	103	101	99	45
46	73	78	82	86	87	88	88	86	83	46
47	61	66	69	72	73	74	73	71	68	47
48	51	54	57	59	60	61	60	58	55	48
49	40	44	46	48	49	48	47	45	43	49
50	31	34	36	37	38	37	36	34	32	50
51	23	25	27	28	28	28	27	25	23	51
52	16	18	19	20	20	19	18	17	15	52
53	10	12	12	13	13	12	11	10	8	53
54	6	7	7	7	7	7	6	5	4	54
55	2	3	3	3	3	3	2	2	1	55
56	0	1	1	1	1	1	0	0	0	56

Notes

[1] For a detailed description of the mathematical derivation of the model see Cardenas, Stranlund and Willis (2000) and Cardenas (2000).

[2] For a more detailed and rigorous statistical analysis of the data using parametric and non-parametric statistics see Cardenas, Stranlund and Willis (2000) and Cardenas (2000), comparing other variables, such as the choice variable X (months in the commons) and Y (individual earnings). The results reported are consistent with the analysis presented here.

[3] Notice that for the last 3 rounds of the first stage the %GroupMax for the REG groups is slightly higher than for the COM groups. However, a Wilcoxon rank sum (non-parametric) test fails to reject the hypothesis that players COM and REG choices were statistically different during the first stage (Cardenas 2000).

[4] Looking at Table 8.1, if all seven players comply with the rule of 1 month in the forest, and the eighth decides to choose 8 months and is not inspected, her earnings go up to 891 instead of the 645 that would produce everyone's compliance. A penalty would cost her, however, 700 points, if audited.

[6] During this conference Georg Grunberg mentioned the case of the Peten Biosphere Reserve in Guatemala where the participation of villagers was key in controlling damage caused by recent forest fires to ecosystems and settlements. He pointed out that in those villages where external aid was higher in terms of technology and support, people responded less rapidly, while those areas where external aid was not expected witnessed much stronger involvement of villagers and more effective control of fires. His observations are consistent with the arguments presented in our analysis.

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