"Rethinking Local Commons Dilemmas: Lessons from Experimental Economics in the Field"

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1. Introduction.

A rather recent development in economics is the formal study of how human groups device ways of governing the coordination of actions that produce externalities without the need of a Leviathan with perfect information and costless ways of enforcing rules, or without the need to individualize the property rights over the resource to allow the invisible hand to coordinate choices and results. *Social Capital* is one of the terms proposed by leading authors like Putnam (1993) to explain those means (e.g. norms or rules) that groups use to govern themselves. *Self-Governance Institutions* has been an alternative notion proposed by others like Ostrom (1990). Or a synonymous, *Community Governance* (Bowles, 1999) which also conveys the same notion[1]. In general, economic analysis is now recognizing that individuals may put in place self-governed material and non-material incentives, which induce changes in behavior from self-oriented actions to group-oriented ones, which may produce outcomes that are collectively Pareto superior than those resulting from the purely selfish and short-sighted behavior of individuals. Usually these institutional arrangements achieve the result of correcting the failures of externalities without the intervention of an external agent or the rearrangement of property rights.

In particular, the academic debate over the best prediction about the behavior of people that use a common-pool resource (CPR), and the recommended policy approaches to the CPR dilemma have undergone a very interesting evolution throughout the last 3 decades of the past century, since the emergence of at least two seminal contributions; Garret Hardin's 'Tragedy of the Commons" (1968) and his reflections on the lack of individual property rights over resources

1 Interestingly, Bowles differentiates how while social capital might be understood as something groups have, community governance would correspond to things people do.

under joint access; and Mancur Olson's Logic of Collective Action (1965) on the difficulties for large and homogenous groups to achieve the voluntary provision of a public good. The empirical evidence on groups using common-pool resources, dating back for centuries, and still today remaining inconclusive, supports in many cases and rejects in many others the different hypotheses available today. Why in some cases groups succeed collectively in managing a resource for which they have joint access, while in similar situations other groups drive the resource closer to exhaustion and socially undesirable results? Why some individuals do act in these situations according to the theoretical prediction of the homo-economicus while others do not?

The fact that these questions remain unsolved should challenge the way the problem of commons dilemmas is taught and studied in the economics profession, and in how it transpires to policy making debates. However, much of the teaching of this particular problem is done without much of the new theoretical, empirical and experimental contributions that have emerged since Hardin's tragedy prediction. Today the problem of the commons is still presented to students as a free-rider problem where the individual rationality of those extracting the resource and the lack of private or state ownership of the resource would drive the common-pool to yields that are socially sub-optimal, and eventually to exhaustion. At best, some authors seem to acknowledge the difference in rights and rules between open access and common property. Nevertheless, the introductory level teaching ignores in most cases the possibility of the groups devising institutions for self-management and control, or the possibility of human preferences that involve the welfare or actions of others. Further, much of the policy textbook recipes still remain within the two orthodox approaches of assigning individual property rights to the resource, or transferring all property and control to the state for a socially efficient management to emerge. However, a long and rich path has been covered by many social and natural scientists that explore the factors that drive human behavior when facing a CPR dilemma.

This paper wants to respond to this concern in two ways. One, by providing in sections 2 and 3 elements from recent advances in the analysis of CPRs that could be easily introduced into the teaching and policy design regarding the social dilemmas arising from the use of commons. In particular, it will call the attention to the lack of importance given to community governance solutions and the focusing on the state and the market solutions, at least in the teaching and policy design arenas. The second contribution to the concern is through a set of results (Section 4) from field experiments conducted in actual CPR settings in rural locations; the results provide empirical evidence of some of the new developments in the literature and question much of the conventional views about these dilemmas.

Further, the methodological approach of applying experimental economics in the field and in the classroom might bring to the economics profession some lessons and challenges about participatory research and teaching techniques where the participants (villagers or students) become active part of the analysis and not mere subjects that produce data, as usually seen in the conventional literature.

2. Literature Evolution: Making the Commons less Tragic, More Complex.

Several steps forward have improved the way human decision making is studied and taught in economics for these last decades. These developments can easily introduced into the teaching and policy discussion of the commons dilemma, and as it will be shown, many outcomes divergent from the tragedy of the commons can be predicted depending on the institutional setting assumed.

First, it was soon acknowledged after Hardin's arguments that a clear differentiation should be made between open access and common property (Bromley and Cernea, 1989), and that the so called tragedy was more likely to occur in the conditions of the former. The debate also advanced by clarifying that the specific characteristics of the assumed production function for the benefits from the use of the common-pool resource would determine how distant would be a socially optimal solution and that resulting from the assumptions that individuals acted in their own interest and without considering the externalities imposed on other users. In particular, Cornes and Sandier (1983) showed that if one considers the strategic behavior of individuals and the possibility of they making assumptions about the behavior of others, the Nash game-theoretical equilibrium would not correspond to the original open access point where average product is equal to average cost of extraction, and only when the number of users approached large numbers, such points would coincide. Sandier (1992) later formalized much of Olson's logic through more specific models and explored further the original propositions on group size and group composition, finding in general that they hold under certain circumstances or assumptions, again, related to the assumed production function. Another major step forward in the literature could be represented by Ostrom's "Governing the Commons" (1990) where existing theories and her vast field work evidence, converged into a set of design principles that seem to explain the conditions under which many groups had been successful in managing a natural resource collectively.

By the early 1990s the use of experiments in economic analysis had reached a certain maturity that allowed several researchers to study the behavior of people under different group externality situations. Several experimental studies on voluntary public goods provision and on common-pool resources expanded the evidence on how complex individual behavior is when facing such group dilemmas. Ledyard (1995) surveyed much of the experimental work on public goods and described a set of weak and strong factors that seem consistent in explaining why humans do not behave as the predicted by the Nash game-theoretical equilibrium, and when they do. However, the difference in the structure of incentives between a pure public good and a common-pool resource problem should keep any extrapolation between the two experimental results from happening[2]. Regarding the experimental evidence on common-pool resources problems, Ostrom, Gardner and Walker (1994) offer a seminal work by setting a whole new area of research using experimental techniques to study the institutional factors that may induce cooperative behaviors by individuals in groups facing CPR dilemmas. Their basic model of analysis and experimental design initiated a wide set of variations about the institutions and policy devices to use to improve the social efficiency in CPR provision. From endogenous to exogenous mechanisms, from monetary to no-monetary incentives, several works have emerged since, to create the conditions when groups self-manage effectively a CPR.

An important lesson that emerges from much of these works is that neither the game-theoretical prediction is very accurate in explaining the empirical evidence from the field or the lab, nor all decentralized (self-governing) mechanisms and institutions guarantee a socially efficient use of the commons. Many equilibria can occur as a result of interactions of institutional factors and incentives intervening in the individual's decision to extract or conserve the resource. Further, both the public goods and the CPR experimental evidence show a wide variation within groups and across them that cannot be explained by variables controlled in the laboratory or the equilibria predicted by the theory. One plausible explanation is the existence of more than one type of rational agents in a group. Ostrom (2000) uses an evolutionary model where there are two types, rational egoists and conditional cooperators, who interact, and depending on the fraction of each on a population, the resulting equilibrium in a collective action situation. The use of evolutionary arguments in the explanation of multiple equilibria is growing fast within the economics literature (Bowles, forthcoming) and it could provide a richer set of modeling techniques for the study of CPR dilemmas.

On the other hand, the two major propositions by Olson, that large groups and that homogenous groups would be less likely to achieve a collective action to sustain the provision of benefits from the public good, are often challenged and cannot be generalized, for reasons pertaining to the assumptions in the production function, and in the individuals rationality model.

Finally, there are the more recent introduction in economics of the problems that arise from transaction costs, asymmetric information, monitoring costs, and costs of enforcing contracts. Such developments have reshaped the study of environmental economics and policy (Lewis, 1996; Spulber, 1988; Segerson, 1988; Dasgupta, Hammond and Maskin, 1980), but are still absent in the analysis of its implications to the problem of CPRs and the natural resource models in the most part.

Therefore, we have seen a long and enriching evolution in economics thinking that although has partially transpired to the environmental economics literature, it has not translated

[2] What I mean here is that although excludability might be shared by both public goods and CPRs, subtractibility or rivalry differ between the two. One unit of resource extracted is not available anymore to anyone in the group while one unit of the pure public good produced and consumed is still available for others to benefit from.

into the teaching and policy design of the commons problem which remains within the basic prediction of the tragedy of the open access resources, and within the policy choices between the market solutions such as transferable quotas and assignment of property rights, or the state solutions such as command and control (technology, quotas) or economic incentives (taxes and subsidies).

Hopefully the discussion that follows and the empirical results from a set of experiments conducted in the field in Colombia can provide some basis for enriching the way we teach and study the problem of joint use of ecosystems in environmental and development economics.

3. Economic building blocks to study the problem of the local commons.

By starting with the simplest CPR problem I will review the steps that the literature has made towards a more complex and complete analysis of the commons dilemma. Such review will provide the basis for comparing the results to be presented from the field experiments and that gave rise to the reflections on this essay.

Imagine a stock of a renewable resource (a fishery, forest, or a water reservoir) that is used by the members of a community. The extracted resource (fish, firewood or water) may be either consumed or sold in the market. For simplicity let us assume that the unit value is the same for both possible uses, and equal to $1. The basic commons problem is derived from a total (aggregate) yield function Y, which depends on the aggregate level of effort *e* by the community to extract the resource, $Y=F(e)$. Given the biological growth and regeneration of this renewable resource, this functions is usually concave, and can take, for instance, the quadratic form: $Y = ae - be^2$, that is, as aggregate effort increases the marginal yield or catch decreases, and eventually Y may decrease if the extraction effort is excessive enough that it harms the biological productivity

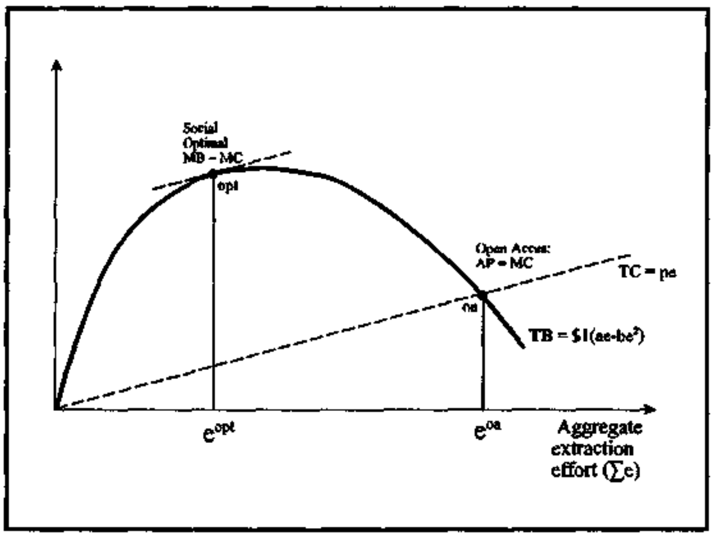

Figure 1. Aggregate benefits and costs in the local commons.

of the ecosystem[3].

If we assume that aggregate total cost of extraction is a linear function of the effort, where p is the unit cost of extraction, then TC = pn. Graphically we can express the model as in Figure 1. The preservation or exhaustion of an ecosystem depends ultimately on the level of pressure that the group of users impose through extraction of matter and energy from such an ecosystem in the form of fuel wood, fodder, food, fiber, and water. Such pressure is a direct function of the aggregate effort (e) that the users devote to extracting these goods and services. The economic problem arises from the opposite effects of using the commons. Too low a level of extraction will guarantee its ecological conservation, but diminish the benefits for the community. Too much extraction will serve the community, but in the long run it will cause its exhaustion and eventual collapse, including damage to biological diversity. The most important economic question then is finding the optimal level of aggregate effort such that it preserves the commons' renewability and maximizes its net economic benefits to the users.

i. The conventional approach to the problem of the commons.

To estimate the social optimum solution where the aggregate net benefits are maximized, and assuming a $1 value per unit extracted, one can assume a social planner or individual decision-maker that maximizes $NB = TB-TC = 1[ae - be^2] - pe$. Then, $\partial NB/\partial e = a - 2be - p = 0$, where $\mathbf{e^{opt} = (a-p)/2b}$ (level of total effort in the social optimum). Such a point (opt) in the graph occurs where the total cost curve is parallel to the marginal benefits curve, i.e. when the aggregate marginal benefits equal aggregate marginal costs. This in fact is achieved with the individual property rights solution. Hardin (1968) argued that a single owner (state or private agent) should concentrate all rights to use a resource in order to avoid its exhaustion. Notice, the solution has assumed that no social costs (distributional or transactional) occur by concentrating the decision in one agent.

Open Access solution: In the absence of a social planner or any type of institution that enforces a control over the resource users, a different outcome results from the extraction of the resource by the members of the community. Under an open access to the resource and the assumption that agents will act selfishly and myopically, Hardin's tragedy takes place. From the standpoint of each commons user, one should increase the individual effort as long as the average yield (Y/e) still compensates for the individual cost of an additional unit of effort. Beyond such point it is not worth extracting the resource. At that point where the average product equals marginal cost, the resource generates no rents. In our model, $AP = Y/e = p \Leftrightarrow (ae-be^2)/e = p \Leftrightarrow e^{oa}$

[3] For simplicity I consider here a common pool that provides one single renewable resource that is extracted and consumed and where $F(e=0)=0$. In reality, and for a more adequate analysis, ecosystems provide multiple sets of goods and services for society. Such goods and services involve different flows of matter, energy and information that make up part of the welfare functions of society. For the design of the field experiments I relax this assumption and introduce the multiplicity of products and services from the local commons, i.e. where $F(e=0)>0$ (Cardenas, 2000).

= (a-p)/b (level of effort under open access). Such a solution, (oa) in the graph, occurs when the aggregate average product is equal to the aggregate average cost. Clearly the tragedy of the open access resources emerges from several facts. First, at this point there are no rents because of the over-extraction by the users. Also, the effort of extraction is excessive, usually beyond the maximum sustainable yield of the resource stock, and will affect in the long run the renewability of the resource.

Nash non-cooperative solution: Through the introduction of a game-theoretical framework, Cornes and Sandier (1983) challenged the open access equilibrium by including the possibility of strategic behavior by the community members, i.e. where agents have conjectures about the behavior of the rest of the commons users. In their model, the users are conscious of how an over-extraction of the resource leads to a decrease in the resource, and they allow agents to take that into account. Their results showed that the level of extraction of the resource will depend on such conjectures and the technology assumed[4].

Continuing with things simple for didactic purposes, let us assume now that a two-member community makes use of the commons. Assume also that the two users distribute the gains of the aggregate harvest proportionally to the effort by each. If $Y = ae - be^2$, and $e = e_1+e_2$, and thus the aggregate harvest is $Y = a(e_1+e_2) - b(e_1+e_2)^2$. The problem for user 1 is therefore, Max $\Pi_1 = (e_1/(e_1+e_2)) * [a(e_1+e_2) - b(e_1+e_2)^2] - pe_1$. This problem yields the following FOCs (Cornes and Sandler, 1983; Baland and Platteau, 1996): $e_1^{nash} = (a - p - b\, e_2^{nash})/2b$, assuming symmetry in the users yields a Nash equilibrium effort for each of the users $e_i^{nash} = (a-p)/3b$ (I=1,2). Thus, the aggregate effort for the commons would be $e^{nash} = 2(a-p)/3b$.

Notice that this result lies between the predicted extreme outcomes of the social optimal and open access equilibrium efforts. Secondly, as the analysis is extended to more users, the Nash effort for each of the players increases which in this particular case would confirm Olson's argument. Let us summarize the first three predictions of our analysis in the following graph (See Figure 2). The points (*opt*, *Nash*, and *oa*) represent respectively the social optimal, non-cooperative Nash and open access outcomes of our problem. They not

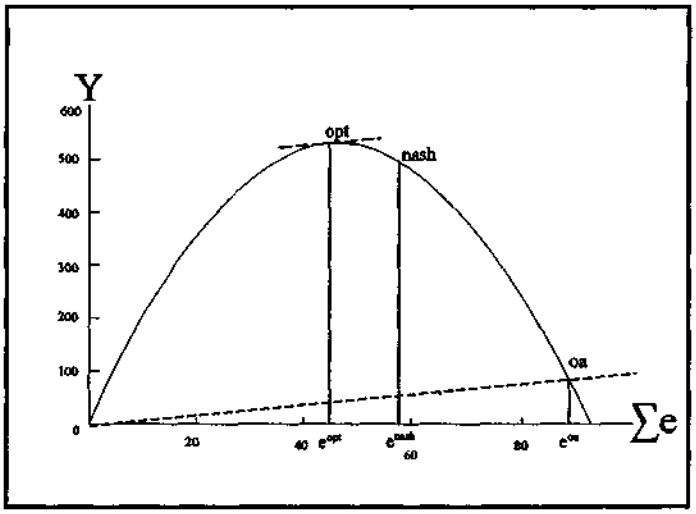

Figure 2. Social optimal, Nash and open access solutions to the local commons problem.

4 In a further extension, however, the group size effect was introduced, showing that as the number of users appr equilibrium effort on the resource approaches the open access outcome.

only vary in the level of net aggregate benefits, but also on the level of effort and therefore pressure on the ecosystems.

Notice however that these solutions have an element in common. They are result of an economic analysis where individuals care only for their own interest, i.e. they involve only self-regarding preferences. I will now introduce social and economic institutions in the problem in order to consider the possibility of different equilibria where other group effects are in play that may induce cooperative behavior by the local commons users.

b. The commons problem as a Prisoners' Dilemma (Game 1)

Why does the Nash result lies in a socially sub-optimal level of aggregate extraction? The individual behavior of the local commons users, up to this point, has considered the balance of the benefits and costs of using the commons, and later it considered the conjectures about the behavior of the other users. This situation can yield for a two-person group a type of prisoners' dilemma (PD) game where the players rationally decide to choose a strategy that yields a Pareto sub-optimal solution, although the game allows for a Pareto superior outcome, if they chose a different strategy. Let us consider the following payoff matrix as an example. Each player or household has to decide between two levels of individual effort (e, or e+1). Higher levels of effort yield individual benefits for the users, but after a certain point too much aggregate effort brings the local commons' productivity down[5].

Table I.1. Game 1: Non-cooperative behavior. PD Game.		Household 2	
		e (cooperate)	*(e+1)* (non-cooperate)
Household 1	e (cooperate)	(10 , 10)	(3 , 12)
	(e+1) (non-cooperate)	(12 , 3)	[redacted]
Values in cells correspond to net payoffs to households 1 and 2 respectively.			

Here the individual (non-cooperative) rationality of each household creates a Pareto inferior outcome where both individual and aggregate payoffs are lower that what they would be able to gain if they decided to cooperate or restrict their effort level to e each. How could we

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[5] In a general form the payoff matrix in Table I.1. will comply with the minimum requirements of a PD game (see matrix below) when A>B>C>D, and 2B>A+D, just like the numbers in the example:

PD Game:		Player 1	
		e	*(e+1)*
Player 1	*e*	B , B	D , A
	(e+1)	A , D	[redacted]

induce the two households to decide individually to choose e as the level of optimal effort and therefore increase the aggregate level of benefits while reducing the pressure on the ecosystem?

c. The commons problem when institutions are introduced.

As we have seen, the equilibrium solution to the problem lies within a range of possible aggregate efforts between the unrealistic but theoretically useful benchmarks e^{opt} and e^{oa}. In order to correct PD game-type situations, society has tried different governance mechanisms to generate Pareto superior outcomes. These institutions can be grouped into state, market and community mechanisms. Based on the model, one could say that the role of institutions in this setting is to shift the level of aggregate effort to the left or right by inducing different responses by the community members. In other words, institutions change the rules of the game, which include changing the possible strategies, the payoffs, or the entire game. I will examine some of the possible mechanisms related to the questions and objectives of this essay.

i. The private solution and the property rights approach (Hardin and Coase)

We have already presented the private solution with the (opt) point in Figure 2, and the optimal aggregate level of effort e^{opt}. This is basically the property rights school proposal which encompasses the assignment of all residual claimancy to one decision maker. For this solution to be implemented, one agent receives all property rights over the resource and all other potential users are excluded from using or having access to the resource. Undertaking such solution to the problem of the local commons and the biodiversity problem is, however, undesirable and unfeasible. The regressive distributional impact could be considerable when restraining entire communities from benefitting from these resources, even if compensated for the reassigning of property rights. Welfare efficiency losses might also be involved. Weitzman's (1974) seminal article showed that the introduction of individual private property rights might be counterproductive when compared to traditional common property access.

But more critical is the infeasibility of such an approach. For ecological reasons the benefits from these ecosystems cannot be divided and assigned entirely to the residual claimant, and totally exclude the rest. The extreme case is the non-use or existence values from the preservation of endangered species which are non-excludable. Secondly, the transaction costs involved in excluding others from using or benefitting from these benefits can be so high that an individual property rights system may be costlier than a communal access system.

ii. The State solution

Given the coordination failures, a common solution would be the intervention of the government in the game. Basically, the regulator could punish the over-extraction with a tax, or compensate those who refrain from doing so with a subsidy. We illustrate below, building on our simple game.

(1) Game 2: A central authority with perfect information (Ostrom, 1990)

In this game the regulator imposes a tax of $3 on those who decide to select (e+1) as the effort strategy. We assume that the regulator has all the information on the effort level by each of the families under costless monitoring. Our payoff matrix is transformed then in:

Table I.2. Game 2: Central authority with perfect information. $3 tax.		**Household 2**	
		e	*(e+1)*
Household 1	*e*	(10,10)	(3,9)
	(e+1)	(9,3)	(2,2)

In this case the tax on non-conservation shifts the Nash solution from [(e+1), (e+1)] to [e,e], which generates both superior aggregate and individual net benefits (a Pareto-superior solution), as well as reducing the pressure over the ecosystem. Nevertheless, this game presents some problems. The main one is having assumed that the central authority is able to monitor, with no social costs, the group of commons users and be able to distinguish the effort level selected by each. We have been arguing all along that severe information asymmetries may be present in the contexts of these agrarian economies with weak governments. If the monitoring and enforcement costs are large enough, the additional transaction costs of such a solution may not be compensated by the gains from the new Nash solution.

(2) Game 3: A central authority with imperfect information (Ostrom, 1990)

We now design a new game where the regulator can monitor with some probability of being wrong, that is, a probability of taxing families who are complying, and not taxing those who over-extract[6]. Maintaining the same $3 tax on those who select (e+1), let us introduce y as the probability of the authority taxing those who in fact chose (e+1) (defectors); that is, the regulator will not tax those who complied with probability (1-y). Analogously, assume a probability x that the regulator taxes incorrectly those who in fact complied by selecting (e). The general form of the transformed payoffs matrix becomes:

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[6] We can think of a situation in which a government applies a Pigouvian tax to a sub-group of society or sub-sector of the economy for an externality. Logically one can expect that within such a taxed sub-group there might be a fraction who should not have paid such tax because they actually did not contribute to the externality. Since the regulator cannot study each individual case unless large transaction costs are assumed, it could be socially more efficient to assume the social costs of such asymmetric information.

Table I.3. Game 3: Central authority with imperfect information (x,y). Tax of \$3 on effort = (e+1).		Household 2	
		e	(B*e*+*1*)
Household 1	*e*	(10-3x, 10-3x)	(3-3x, 12-3y)
	(*e*+*1*)	(12-3y, 3-3x)	(5-3y, 5-3y)

The levels of precision on the information available to the authority will determine the Nash solution to this game. Let us review some examples. In game 3a we have assumed probabilities x=0.3 and y=0.7, i.e. the authority is about 70% right in both taxing those not complying at e, and 70% right not taxing those complying. The resulting payoffs are then:

Table I.4. Game 3a: Central authority with imperfect information (x,y). Tax of \$3 on effort = (*e*+*1*). x=0.3, y=0.7		Household 2	
		e	(*e*+*1*)
Household 1	*e*	(9.1, 9.1)	(2.1, 9.9)
	(*e*+*1*)	(9.9, 2.1)	(2.9, 2.9)

Such level of precision by the government is not sufficient to transform the original PD game into one where the rational strategy is choosing e as the individual level of effort. The solution is Pareto inferior and over-extraction of the resource results.

Among the sets of experiments we conducted in the field, those where we introduced a similar probabilistic external regulation showed a similar result this where the individual rationality along with the probability of inspection drove players to choose strategies closer to the Nash prediction of higher levels of extraction of the commons.

However, increasing the level of accuracy of the regulator, our Game 3 can yield different results as shown in Game 3b where the probability of correctly applying the tax is 90% (i.e. 1-x = 0.9; y=0.9).

Table I.5. Game 3b: Central authority with imperfect information (x,y). Tax of \$3 on effort = (*e*+*1*). x=0.1, y=0.9		Household 2	
		e	(*e*+*1*)
Household 1	*e*	(9.7, 9.7)	(2.7, 9.3)
	(*e*+*1*)	(9.3, 2.7)	(2.3, 2.3)

In this case the regulation can induce in each of the households to choose e instead of (e+1) as effort levels. This outcome, an Assurance Game (AG), is clearly Pareto superior and the aggregate effort (2e) is less than the over-extraction level (2e+2).

The final thought on this game 3 is to what extent the regulatory agencies can with accuracy and minimum transaction (monitoring and enforcement) costs correctly identify the levels of effort and use of commons in order to apply a tax, or its equivalent the subsidy, in order to induce a change in the individual behavior. Unfortunately the governments when dealing with these situations face not two but hundreds, thousands or hundreds of thousands (depending on the government level) of economic agents involved in local commons dilemmas.

The regulator's probability of correctly applying the incentive discussed depends on at least two antagonistic forces. Lower levels of government have in their jurisdictions smaller groups to monitor, and eventually can take advantage of self-monitoring mechanisms that will be discussed later. Higher levels of government can benefit from economies of scale in monitoring techniques of control not available to smaller regulators. In the control of forest clearing, for instance, a local government may have better (more frequent) direct field contact with those clearing forests for logging and firewood extraction, and may have better information on their production cost functions. However, national governments can on the other hand make use of remote sensing technologies (GIS) for monitoring at a larger scale the areas being cleared. An additional question emerges regarding which type or level of government is more likely to enforce the tax.

iii. Cooperation and the Community Solution (Game 4)

Another type of decentralization has been suggested in the literature as a possible solution to the commons dilemma —decentralized self-governing institutions providing the norms or rules for inducing the level of effort in the community members, without the need for an outside regulatory agency. In this community solution, the individual preferences and decision making involve elements associated with the group effect that is derived from the externalities inherent in the commons problem. Whether because the individual's utility function directly involves variables associated with the welfare of the rest of the group, or because the utility function includes variables of rewards and punishments by the group to the behavior that affects the entire community, the economic analysis changes dramatically from the original Nash non-cooperative behavior discussed so far. Ostrom (1990) approaches the problem of decentralized solution by adding a cost for the members to achieve an agreement. The treatment we will develop here will be based on a repeated game in which reciprocity and learning induce the community members to assume a conservationist strategy rather than free-riding on the commons because of the mutual benefits over time. The argument is based on Axelrod's (1984) discussion of cooperation, the *"nice-tit-for-tat"* strategy and further developments on reciprocity, retaliation and cooperative behavior (Fehr and Tyran, 1996; Fehr and Gachter, 1998; Bowles and Gintis, 1997, Ostrom, 1998). Fehr and Tyran (1996) provide strong and extensive experimental evidence on how many of social relations within individuals are based on reciprocal fairness. Altruism, on the other hand, has increasingly been recognized in the literature (Andreoni, 1995) as an important component of individuals' preferences.

Furthermore, empirical evidence from large case studies and statistical support are emerging to demonstrate that members of communities, rural or urban, are willing to cooperate in the provision of local public goods. Wade's (1988) village republics in India, Putnam's (1993) social capital analysis in different regions in Italy, and more recently the study by Sampson et.al. (1997) on the violence in urban neighborhoods in Chicago, which analyzed the levels of involvement by neighborhood members in intervening at different situations which threatened the local public safety. What the latter study showed is that community members were willing to cooperate in the provision of such an important local public good, safety, by directly intervening in the problem.

Our next Game 4 models this phenomenon by transforming our initial game 1 into a repeated game adding reality to the situations faced by the rural communities managing local commons, where economic relations among the community members are repeated over time. The net benefits are then discounted at a social rate, r, and added in order to analyze the different possible strategies that the players can play. In order to introduce the "community" effect in the model, a probability, p, of repeating the relation with the same household in the future is added. When considering the general form of the PD game (See footnote above), one can estimate the present values of different strategies. Let us consider two simple strategies. One, the previously mentioned *"nice-tit-for-tat"* (TT) (Axelrod, 1984) where the player starts cooperating and from then on repeats whatever the player did the last time. The second strategy chosen, for purposes of contrast, could be an unconditional defector (DD) who defects on all rounds. Recall that in the one shot PD game, defection is the Nash strategy, and it brings the highest payoffs to the defector when the other player cooperates. The strategies in our model will no longer be e, and (e+1), but a series of combinations of these over time. Evaluating, for instance, the net present values of TT, when facing another TT, the player starts cooperating, i.e. choosing e, and faces the same TT the next time with probability p, yielding[7]

$$E(TT,TT) = B + pB/(1+r) + p^2B/(1+r)^2 + p^3B/(1+r)^3 + ...+ p^nB/(1+r)^n +.... = B(1+r)/(1+r-p)$$

Similarly, the other expected values can be calculated generating the following payoff matrix:

Table I.7. Game 4: Repeated game - present values.		Household 2	
		(TT) nice tit-for-tat	(DD) Unconditional defection
Household 1	(TT) nice tit-for-tat	[B(1+r)/(1+r-p), B(1+r)/(1+r-p)]	[D+C(p/(1+r-p)), A+C(p/(1+r-p))]
	(DD) Unconditional defection	[A+C(p/(1+r-p)), D+C(p/(1+r-p))]	[C(1+r)/(1+r-p), C(1+r)/(1+r-p)]

[7] Recall that in a time series, $1+B+B^2+B^3+B^4+B^5+...+B = (1-B)/(1-B) = 1/(1-B)$.

In order to evaluate the Nash solution to this game, let us assign the same payoffs for the past games (A=12, B=10, C=5, D=3). For the discount rate, we will use a value of r=5% compatible with the environmental discussions. And finally, a first value of p=0.1, that is a 10% chance of meeting the same household in the future, to start our discussion of the "community" effect on retaliation and reciprocity as mechanisms of self-correcting the failures from the PD games. Such values yield the following payoff matrix:

Table I.8. Game 4a: Iterated game - low probability (p=0.1) of meeting the same household.		Household 2	
		(TT)	(DD)
Household 1	(TT)	(11.05, 11.05)	(3.53, 12.53)
	(DD)	(12.53, 3.53)	[illegible]

The resulting payoffs correspond to the same characteristics of the PD game since (12.53>11.5>5.53>3.53) and (11.05+11.05)> (3.53 + 12.53). Such a low level of "community" has not transformed the original game and over-extraction of the commons persists. When increasing the probability of repetition of the game between the same households to p=0.5, a new net present values result in the following payoffs (Game 4b):

Table I.9. Game 4b: Iterated game - medium probability (p=0.5) of meeting the same household.		Household 2	
		(TT)	(DD)
Household 1	(TT)	(19.09, 19.09)	(7.55, 16.55)
	(DD)	(16.56, 7.55)	(9.55, 9.55)

A rather different game results. Now we have two possible Nash equilibrium, one (TT,TT) which is Pareto superior to the other. Notice also that the differences between the payoffs are small, and thus difficult to predict which outcome is more likely. When evaluating the model using a larger value for p, however, those differences increase dramatically. For instance, when p=0.9, we obtain Game 4c:

Table I.10. Game 4c: Iterated game - high probability (p=0.9) of meeting the same household.		Household 2	
		(TT)	(DD)
Household 1	(TT)	(70, 70)	(33, 42)
	(DD)	(42, 33)	(35, 35)

Several issues emerge from this new game. First, without altering the rate of discount and with the same initial values, the expected payoffs have greatly increased as a result of a greater frequency that the households benefit mutually from social interaction based on reciprocity and cooperation, i.e. maintaining the individual effort on e and reciprocating to the actions of the other household. Secondly, the difference between the payoffs has increased enough that households would clearly distinguish between the two Nash equilibria and would be more likely to choose TT as the preferred strategy.

The literature about cooperative behavior in the use of common property resources is large and diverse. Earlier works like Field (1985, 1989) explore the transaction costs involved in operating a system of communal plots of land by comparing the costs of excluding non-users from accessing the commons with the costs of transactions among the users of each common. As the number of commons increases, the exclusion costs increase, but the costs of transactions are reduced since each commons involves fewer individuals. Later on, Ostrom, Walker and Gardner (1994) compiled several years of empirical and experimental work on common pool resources providing some suggestive conclusions about the conditions under which groups will be able to self-regulate in the use of a common-pool without over harvesting it. Among the most relevant results from this work is the enhanced role of communication among group members prior to the individual decisions, and a rejection of the 'cheap talk' assumption[8] (Ostrom, 1998). *"Exchanging mutual commitment, increasing trust, creating and re-enforcing norms, and developing a group identity appear to be the most important processes that make communication efficacious".* As I will later show, the field experiments we conducted do confirm these arguments in favor of community governance solutions to CPR dilemmas.

Other forms identified in these studies as explanatory of the capabilities of common-pool self-governed by groups are the innovation in the creation of a variety of norms and rules, and the use of resources for monitoring, punishing and rewarding individual behavior. Reciprocity norms, which appear to be central from the experimental evidence worldwide, are strong factors in determining the behavior of group members when facing a collective action dilemma. In a recent work, Moir (1997) has taken from Ostrom, Gardner and Walker (1994) and expanded into the issue of monitoring and sanctioning in common-pool resources. Within the same common-pool model, he compares the baseline model where no communication is allowed and a typical commons problem exists, with two alternatives: one, that group members may monitor the behavior of the others, and another, where members can sanction the non-optimal behavior of others. The main results suggest that monitoring alone may not help correct the coordination failure by reducing the aggregate level of extraction from the common-pool or by increasing the efficiency gains, but sanctioning involving the actual enforcement of rules is in fact effective in controlling extraction levels and increasing efficiency.

iv. Group Heterogeneity: Inequality and Asymmetries in the Commons.

Regarding the effect of inequality in the commons problem, the most important start point

[8] Ostrom (1997) mentions a "*...meta-analysis of over 100 experiments involving over 5,000 subjects, [where] opportunities for face-to-face communication in one-shot experiments significantly raises the cooperation rate, on average, by more than 45 percentage points.*"

is Olson's (1965) Logic of Collective Action. In Olson's explanation, in a privileged group the wealthier members who have comparatively more interests in the public goods from cooperation, will contribute more to its provision, and the less privileged will then be able to benefit from such cooperation by free-riding. However, there are contrasting views suggesting that asset inequality could diminish, rather than enhance, the provision of the public good by the individual contributions of the members of the group (Dayton-Johnson and Bardhan, 1996; Baland and Platteau, 1997; Bardhan, Bowles and Gintis, 1997). Their response to the Olsonian prescription is that the net effect of the privileged group in the final local commons outcome depends on several other factors, and that it may not necessarily be positive. Dayton-Johnson and Bardhan, for instance, raise the possibility that rich members may exit the group attempting to provide the public good rather than cooperate or free-ride on the provision by others. Baland and Platteau, on the other hand, argue that although the wealthier users may indeed have a greater incentive to cooperate, other issues involved in the problem may affect the net result.

Bowles and Gintis (1996), and Bardhan, Bowles and Gintis (1997) argue that asset inequality undermines efficiency-enhancement possibilities because of the asymmetries and the costly enforceability of the contracts between the agents sharing the externality —being in this case a public good ecological externality among the local commons users. Furthermore, and as in the case of Dayton-Johnson and Bardhan, these works claim that different types of inequalities (e.g. assets, exit options, power to enforce, fallback position) generate different effects on the equilibrium result, and therefore different types of redistribution will be more effective than others in the social outcome —in this case the achievement or failure on preserving the local commons resources[9].

Baland and Platteau (1997) suggest a model to explain the collective action problem that a group of farmers may face when dealing with soil erosion control practices (e.g. antierosive barriers[10]). Typically, an isolated contribution by investing in a barrier in his own farm will not contribute to increasing the state of the local commons (soil quality), unless a sufficiently large number of farmers in the village undertake such investment. Their results show that different Nash equilibria emerge depending on several assumptions in the model. A first result shows that the individual's incentive to invest in the local commons is an increasing function of the number of cooperators in the village. On the possible equilibria resulting from the model there is the tragedy of the commons outcome where non-cooperation is a Nash equilibrium, yielding a Pareto inferior result although the collective result of cooperation is Pareto superior as in any PD game.

[9] The rural inequality and poverty questions are then somehow related. In a methodologically interesting paper Reardon and Vosti (1995) argue that there are several types or components of asset poverty in rural contexts, and each of them may have a different relation with possible environmental outcomes. Rural poverty could be in terms of natural resources assets, human resources poverty, on-farm, and off-farm assets (physical and financial).

[10] Other types of local commons are mentioned in their paper such as watershed management, wind erosion control, water erosion control, fishery management, forestry management, and weed and pest control management. All of these involve a typical collective action dilemma situation at the village level.

However, the opposite extreme of the spectrum shows that when the individual investment cost is low enough, or the expected benefits from such cooperation are large enough for the smallest of the farmers, there will be sufficient incentives for individual (noncooperative) cooperation and therefore individual and collective efficient outcomes result from all individuals building the erosion control barriers. The possible outcomes in between these extremes, coordination failures as they label them, will present different equilibria situations with respect to the incentives required for individuals to cooperate depending on several factors modeled. Of particular interest for our discussion is the case where non-identical agents interact in the village. Their model shows that the net effect of land inequality in the incentives for landowners to invest will be the result of two effects working on opposite directions. The large landowners will have an extra incentive in conservation measures given their larger stake in the village local commons. However, such inequality also reduces the incentives by the smaller landholders who see their incentives to cooperate reduced. The result is inconclusive, and so they argue that policy interventions in the agrarian structure would not have a definite effect on the incentives for village members to contribute to the conservation of local commons.

v. New emerging elements on the local commons dilemma.

Throughout this literature we can extract a set of important results that provide a richer view of the problem of the CPRs:

(1) There are important transaction costs that reduce the possibilities of first-best solutions to the commons problem through the private and state alternatives.

(2) The structural constraints to the local users (or best next alternatives) have a direct influence in the individual decision making of preserving or exploiting the natural resources contained in the local commons, with direct effects on the aggregate provision of ecological goods and services to the entire community and the outsiders.

(3) Self-governing institutions based on reciprocal fairness and/or altruistic preferences in the community members may emerge and induce solutions to the local commons problem that do not require external intervention or reallocation and individualization of property rights.

(4) The structure of the games within the community may change through the intervention of the outsiders, but the net effect on effort and net benefits is inconclusive.

(5) Inequality may reduce the possibilities of correcting the coordination failures arising from the commons dilemmas when asymmetric information and power are present either within the community or between the outsiders and the local users.

4. Testing new theories: Bringing the experimental lab to the field.

Much of the emerging results from institutional analysis and the introduction of problems of transaction costs, and incomplete information have been tested through economic experiments with important results that are challenging the neoclassical paradigm of a costlessly running economy of pure private goods and no externalities (Kagel and Roth, 1995). While experiments have been very helpful to confirm with evidence the power of markets in solving the problem of allocation and exchange in perfectly competitive systems, they have also been very powerful in showing that individuals would not behave as the homo-economicus model predicts in situations where there are external effects among agents. The special cases of public goods and common-pool resource dilemmas are examples where experiments have provided a very rich of results on the role that institutions have in inducing behavior away or towards Pareto superior outcomes (Ledyard, 1995).

We brought an experimental economics design of a common-pool resource dilemma to the field and invited around 200 actual CPR users to participate in a set of economic exercises to test some of the new developments in the literature in a setting where the experiment decision makers are more familiar to the theoretical questions. The results, we believe, can enrich the development of the literature in local commons, the methodological literature on using experiments and the implications for teaching and designing policies aimed at solving the CPR dilemmas.

The details of the experimental results that follow can be consulted in several sources (Cardenas, 2000,1999; Cardenas, Stranlund and Willis, 2000) and I will only present here a review of the relevant results to the discussion. In particular, I would like to present how different institutions affected the outcomes in terms of the social efficiency achieved by each, and how these compare to the different theories discussed above.

a. An economic experiment in the field.

We designed a CPR experiment and brought it to the field in the summer of 1998 to three villages in Colombia to learn from the behavior of actual users of common-pool resources. Through a simple decision-making exercise in which eight participants in each group make repeated economic decisions that have salient economic incentives (in kind and cash) and with the kind of externalities discussed above. The average earnings, about two minimum wage days of work, at the end of the sessions compensated for their time participating in the experiment and in a community workshop held at the end in each village.

In brief, during the experiment each participant had to decide in each round the number of months (from 0 to 8) that she would allocate to extract resources from a jointly used forest. The net earnings from such decision, which she could view in a payoff table, were increasing in her individual allocation, but decreasing in the total group's allocation, giving rise to the group CPR dilemma. To complete the earnings structure, any month not allocated to extract from the forest would yield a constant marginal private return equal to all players. We chose the parameters of the payoffs structure such that if every player choose 1 month in the forest, for a total of 8, they would achieve the social optimum solution where group earnings would be maximized. And if each player chose 6 months, they would find themselves in the Nash sub-optimal equilibrium. The participants in all cases had to make a series of decisions (rounds) under no possibility of interaction among themselves, and then depending of the sample, they would face a different institution either face-to-face communication among the players, or an external regulator that would enforce a certain social norm aimed at improving social efficiency. Also we introduced for some cases a payoff structure to emulate the case of asymmetric incentives where two of the players had a much better opportunity cost of time not allocated extracting the forest, while the other six a much worse than the baseline symmetric case.

The payoffs structure described creates a curve of social efficiency like the shown in Figure 3 where we show the group efficiency[11] as a function of group effort. This situation is very similar to the case of most CPR situations where the social optimum is achieved at an interior solution after which group efficiency decreases with aggregate effort extracting the commons. Notice the two benchmarks described earlier, the social optimal solution when each player chooses 1 month (i.e. 8 months group total) and social efficiency is at 100%, and the Nash solution where each player chooses 6 months (i.e. 48 months group total) where efficiency for the group is only at 24%.

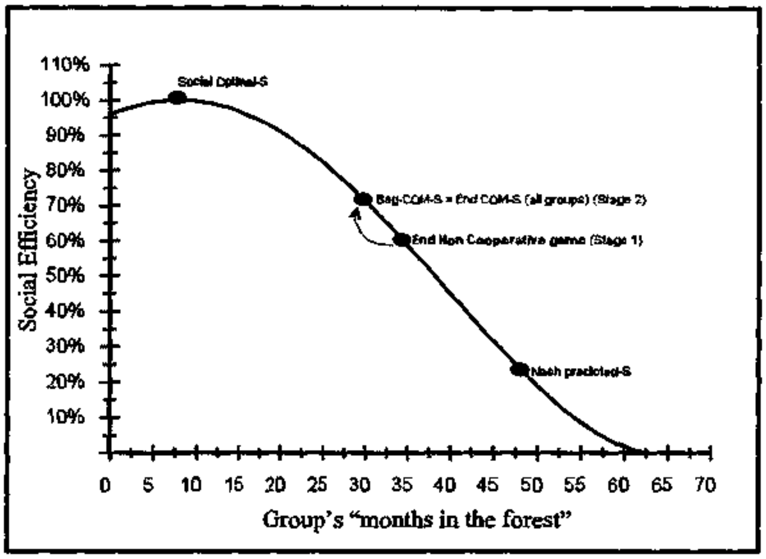

Figure 3. Social efficiency and the effect of non-binding group communication.

As said before, all groups participated in a first stage (Non cooperative game) where for several rounds they had to make the individual choice

[11] Group efficiency is calculated as the actual group's earnings divided by the potential group's earnings had they played the social optimum strategy.

without any possibility of communication or coordination of actions with others in their group. The only publicly known information they had at each round was the total group's months in the forest which determined along with their individual decision the earnings for that round.

For ten of these groups in the second stage we introduced a new rule where they could have a five minutes conversation before each round decision. Such conversation would be free but would not permit any threat or promise of transferring earnings after the session. They would make choices for another set of around 9-10 rounds under this new treatment.

Two observations begin our discussion of the behavior of people when facing these kinds of dilemmas. First, as shown by the point *"End Non Cooperative game"* in Figure 3, under no institution for coordinating actions, still individuals do not make choices according to the Nash prediction. At the end of the first stage (last three rounds) the ten groups participating where allocating in average around 34 months in the forest, for a group efficiency of little less than 60%. Therefore, the symmetric Nash prediction does not prove useful in this case for predicting the behavior of individuals under a setting of private and non coordinated choices like the one existing in the first stage.

The second observation which confirms a now wide and consistent pattern of results in the experimental evidence, face-to-face communication proves to be a powerful mechanism for inducing more cooperative behavior. The results reject in general the "cheap talk" argument that when agents make promises with no enforceable consequences, such promises remain as such and moves towards cooperative choices do not happen. Our results showed that in average the ten groups improved social efficiency by about 10% thanks to the communication. Although the result may seem small, it should be noted that this is the resulting social efficiency at the end of stage 2, and that during some rounds the average was above that. Secondly, and maybe more important, some of the groups achieved levels of almost maximum social efficiency, while others achieved almost no improvement despite all groups facing the exact same incentives and laboratory environment and rules. This point will be discussed next.

b. Who are you playing with matters.

The wide variation of behavior and outcomes across and within the 10 groups is very much consistent with the rest of evidence in the literature (Ostrom, Gardner and Walker, 1994). It can not be explained through the lab institutions and environment since they are all the same in all groups. It might be explained by the individual data and the specific conditions in each round in terms of ho, for instance, reciprocity and learning effects determined choices in one round as a function of choices in previous rounds. But also, the time allowed for the discussion allowed each group in particular, and each individual, to construct a new image of the game, that is a new set of internal payoffs now in terms of utility and not necessarily of monetary values. Guilt, respect, spite, could all be now affecting the choice after a few minutes of debate over what should be a better choice to make in the next round. Given the non-observability of such values, we wondered if certain variables about the demographic, economic and social characteristics of the players and the others in their group might explain such variable behavior. Indeed it did -at least statistically- in several ways. One of them, group composition, seem to determine how effective the communication could be to improve cooperation and social efficiency. We estimated the material wealth in terms of land, livestock and equipment) of each player and estimated also some indicators of wealth inequality for each group. The results of the implications are discussed in detail in Cardenas (2000a) but the following graph (Figure 5) can describe one of the main points. Of the 10 groups we separated the 3 more and the 3 least homogenous in terms of the standard deviation of individual wealth for the 8 participants in the group. While the least homogenous barely improved efficiency through communication, around 3% gain, the three more homogenous or equal groups achieved levels of 85-90% at the end of the communication rounds. In a similar fashion, Alesina and La Ferrara (1999) showed from a General Social Survey (1974-94) sample from U.S. citizens that the participation in social activities decreased with more unequal and more racially or ethnically heterogenous groups.

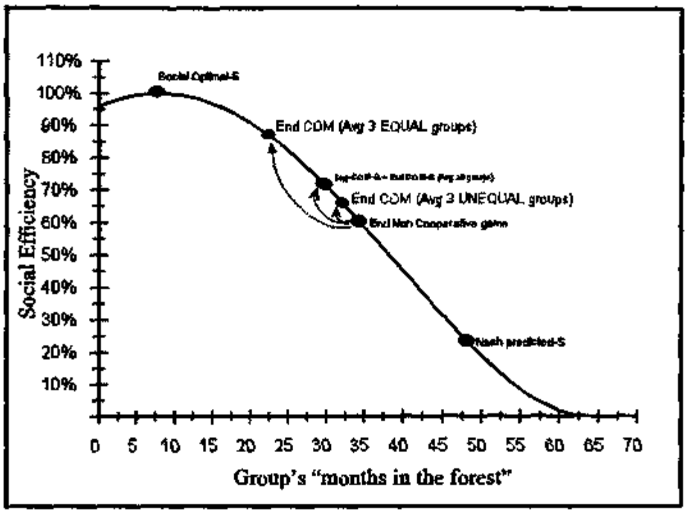

Figure 4. Social efficiency and the effect of wealth heterogeneity within the group.

Further, in Cardenas (2000b) it is shown econometrically that at the individual level, players chose during the second stage lower levels of months in the forest if the difference between their wealth and the average of the wealth of the other seven players was smaller, other things held constant. Also, those players whose real life income was less dependant on private assets like land, and more dependent on the use of a commons behaved in the lab more cooperatively. Interestingly no statistical significance was found on possible explanatory relations between lab behavior and demographic variables like age, education, or gender at individual or group levels.

c. Asymmetric payoffs: Different exit options.

The results above showed how voice and loyalty within the group improved outcomes through communication and through self-governed ways, and that besides the pure material incentives, who is in your group along with your own experience in similar dilemmas determine your choices. Your exit options should also affect the choices, and in fact this is how much of the theoretical literature has dealt with the problem of inequality. Asymmetric payoffs create different incentives to contribute to the public good or refrain from doing so. Olson's argument of the privileged group goes along these lines, that if a privileged member of the group individually benefits from providing the public good, she might provide it despite the free-riding of the others in the group. That is, if the marginal returns from contributing to the collective action are higher for some, they are more likely to cooperate[12]. However there is another side to this problem. It might be the case that the marginal return from not contributing is also asymmetric, that is, that the opportunity cost of allocating effort into the private next best alternative is different for some in the group. In other words, that some may depend more on the commons because their marginal return on their private alternative is much lower due to wealth effects. We introduced such case into our field experiments in five new groups of eight people by assigning different payoff tables to the eight participants in the following way: Two of them, randomly chosen, would receive payoff tables (H) that included a much higher marginal return on months not allocated to the forest, while six of them would receive tables (L) that would get tables where the earnings included much lower marginal returns on the months not allocated in the forest. The Nash theoretical equilibrium for this game would predict that those players with the L tables should allocate their entire eight months in the forest, and therefore those with H tables should not use the forest (i.e. choose zero months) since their best alternative is much better at such point. These asymmetric (HL) groups went through the same two stages as the symmetric baseline groups (S), that is, stage 1 where no communication is allowed, and stage 2 where five minutes of group discussion was allowed before each round decision.

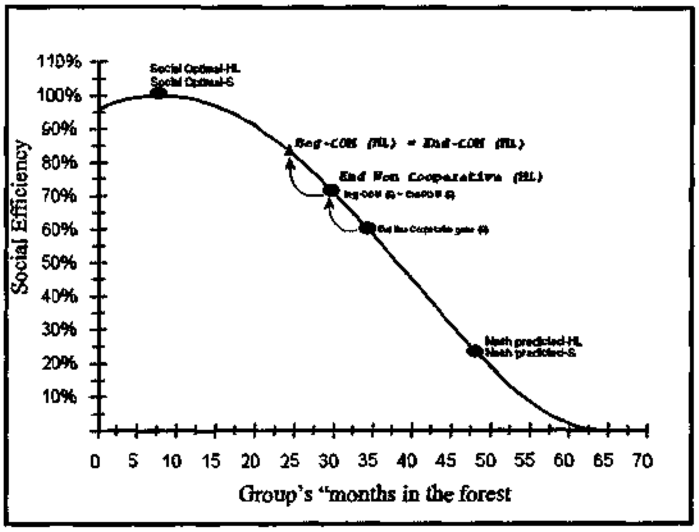

Figure 5. Social efficiency and the effect of asymmetric payoffs structures.

Once again the experimental results would not confirm any of this behavior and provided another interesting sets of results described in detail in Cardenas et.al. (2000) and summarized in the following graph (Figure 5). Notice that the social optimal and Nash benchmarks are quite comparable for the two types of games, mainly because the group average marginal return on the private alternative was the same for both treatments, and the marginal returns from the forest was equal for all group members.

The first observation results from comparing the end of the Non cooperative game (end of stage 1) for the two types of payoffs structures. By the end of stage 1 we already noticed a difference that at first glance would confirm Olson's proposition that heterogeneity increases

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12 Sandler (1992) develops the Olsonian propositions in detail and shows that depending on the production function for the public good, such claim may or may not hold.

collective action. Drove by the payoffs incentives we could conclude that the asymmetric groups achieved higher levels of efficiency (around 72% for HL groups vs 60% for S groups). However, these outcomes did not result from the privileged group argument, but from a rather opposite effect. The six players that had the L tables by the end of the stage 1 deviated further from the expected Nash behavior and towards more cooperative behavior, and this happened without any institution or coordination among themselves. Clearly from the tables one could observe that at the levels of high extraction predicted by the Nash equilibria, earnings were quite low and any reduction in individual choices would bring improvements to the group and to each individual.

The introduction of communication in stage 2 then reinforced this process. The discussions called for reducing the individual months in the forests, but it was only the L players who showed statistically significant changes towards even more cooperative behavior while the two H players remained within the same individual levels they were choosing before communication. This combination of factors induced a group increase in earnings and therefore in social efficiency as shown in Figure 5. Chan et.al. (1996) have shown similar results from a pure public goods experiment, but direct comparisons must be made carefully because the CPR and public goods incentives are different in nature. Nevertheless, they found that when they introduced asymmetric income distributions within groups, aggregate contributions increased but because of a comparatively higher contributions by those endowed with higher income levels.

i. The Role of the State: Crowding-out of Group Oriented Behavior[13]

In another set of experiments we changes the rules of the game for the second stage while maintaining the same conditions for stage one as the baseline groups, i.e. the new five groups still faced the incentives of the baseline treatment with the symmetric tables that the 10 groups under communication had. Therefore, we still have the same benchmarks for the social optimal and the Nash symmetric equilibria to compare the actual behavior to. For the second stage, however, we introduced the role of a social planner with capabilities of enforcing a rule, but with imperfect information. At the end of the first stage we announced to the participants that an external regulator had realized that by each player choosing one month, the group could achieve the social optimum solution, and that in order to enforce such rule the regulator (i.e. the monitor) would choose randomly with a probability of 1/16 a player for inspecting and applying a penalty in case the player was not in compliance with the rule. Such penalty of Pesos $100 for each month in excess of the rule, would be of about 15% of the earnings had the entire group complied. Given the expected cost of the penalty the game-theoretical prediction would expect the regulation to improve the social efficiency of the Nash equilibrium from a level of 24% to a 42% level.

These benchmarks and results are summarized in Figure 6. Given that these new five groups did not face any difference in incentives for stage 1 than the original ten groups, at the end of the first stage they all achieved -as expected- the same social efficiency of about 60% at a

13 Results summarized from a larger paper (Cardenas, Stranlund and Willis, 2000 forthcoming).

group extraction effort of 35 months. Once the new regulation rule is established for stage 2, an interesting phenomena occurs. The immediate reaction of most players is to comply with the rule (Beg-REG-S in Figure 6) by reducing their months in the forest and yielding average levels of efficiency of more than 80%. But right after that first round under the regulation, several players begin to increase their months in the forest driving efficiency down at rapid rates due to negative reciprocity effects on the rest of the group. By the third round with regulation they were already at the same efficiency levels than at stage 1. Efficiency continued decreasing down to the point described as End-REG-S for the last 3 rounds of stage 2. Clearly the regulation did not achieve much improvements, and if compared to either the stage 1 under a non-cooperative game or the communication groups, we could say that they ended up much closer to the expected Nash behavior predicted by the self-regarding model than in a more cooperative outcome. One plausible explanation described in Cardenas et.al (2000) is that the explicit monetary incentives drove the participants away from a group oriented behavior and towards a more individualistic actions because of what Frey (1997; Frey and Jegen, 1999) calls the "crowding-out of intrinsic motivations". Notice also that the points in the graph for the actual data are below the social efficiency curve. This is because under the regulation regime the penalties result in social losses for the group as a whole and therefore the actual group earnings should decrease.

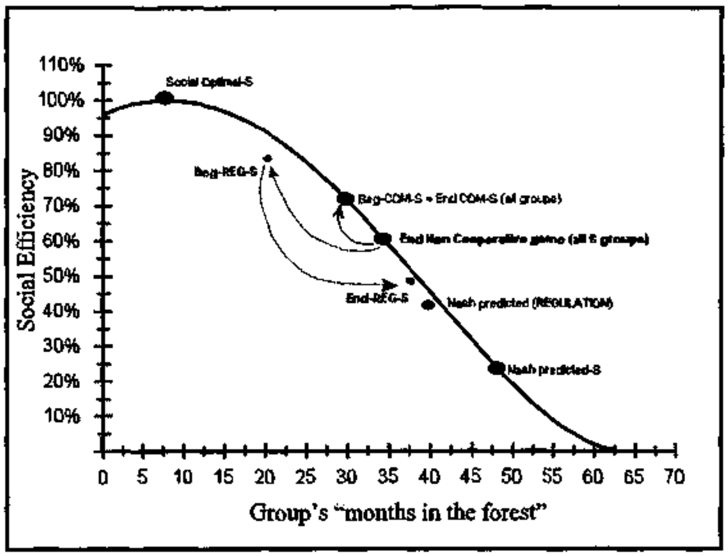

Figure 6. Social efficiency under an external regulation with incomplete information.

5. Beyond the Tragedy: Lessons for studying and teaching commons dilemmas.

a. Institutions and policies for sustainable management of the commons when information is incomplete.

Many institutional factors determine that individuals produce through their actions outcomes that are closer or not to a social optimal solution to the CPR or commons dilemma. The so-called New Institutional Economics school has introduced the problems of transaction costs and incomplete information into the micro analysis of economic behavior. New theoretical models, more field work and the expanding experimental evidence show that institutions matter in economic decision-making in at least the following ways:

i. In most cases individual preferences involve a combination of self and other regarding motives and using the homo-economicus model as a start point has proven useless when individual actions have consequences on others;

ii. Equity and efficiency cannot be separated when contracts cannot be fully enforced and when information is asymmetric;

iii. Groups can device, through social norms, monitoring and non-pecuniary incentives, the means for self-governing their conduct when externalities affect social outcomes;

iv. Intervening through economic material incentives must also take into account the side-effects on behavior and the risks of triggering negative reciprocity and the emergence of self-regarding preferences only.

Through a simple sequence of models and a rather elementary experimental design we have explored some of these issues in the field, and with clear applications to the classroom. It
% seems that it should not be very difficult to introduce these new elements of the institutional analysis into the textbook teaching and policy debate of the problem of common-pool resources.

b. Lessons for the Classroom, Experimental and Field Research.

Sanz de Santamaria (1992) brings to our attention the value of Paulo Freire's legacy on the rethinking of the student-teacher and the social scientist-subject relations. Through his own economic research, Sanz de Santamaria puts it quite well when he highlights the *"crucial importance of the collective participation by academics and the investigated' communities in the processes of production and use of economic knowledges that will affect the living conditions of these communities. Attaining this participation requires tremendous efforts in the construction of communication channels between science (economists) and society (the investigated' communities). These communication channels can be constructed only if economists are willing to stop ignoring (abstracting from) in their concrete research practices the cultural complexity of how the communities they investigate' perceive their own realities" (1992:19).*

I clear example can illustrate the value of this rethinking of economic analysis in the case of experimental work and field work. The community workshops held at each of the three Colombian villages were conceived as a two-way flow of information. From the researchers to the community because of a simple ethical reason: we wanted to tell them the reasons for such exercises, for using monetary incentives and for studying the different rules introduced in the game. In the opposite direction there was mainly a scientific reason. Given the variation found across groups, we wanted to ask them plausible explanations of why different behavior happened within groups and the effects on outcomes. Here the community workshops proved very powerful. The participants gave a variety of explanations which led me to explore some of the hypotheses that I have mentioned before such as the "social distance" hypothesis for some groups to be more effective through face-to-face communication to increase group earnings. Further, some pre-conceived hypotheses that the lack of education or age variations could create problems both methodologically and in terms of the results proved wrong through these conversations.

There is yet another reason for using experimental methods in the field as complementary to the lab, and it might have to do with the concerns that Loewenstein (1999) rises about the external validity of experimental economics and the risks that experimental economics still faces. Field experiments -as compared to experiments with college students- might be useful for researchers for at least three reasons. First, it can provide an environment in which the participants in the experiment are more familiar with the theoretical question of the study and therefore their lab behavior and reactions to institutional changes might be close to reality. And as mentioned before, their own experience in similar situations might be a powerful source for a participatory analysis of the problem.. Secondly, a wider variation in certain individual characteristics of participants such as demographic, economic and cultural variables might be very useful for explaining experimental behaviors that can be the result of not only experimental institutions but also personal values and preferences brought into the lab from outside. Such lack of variation in college students pools might restrict the possibilities of such analysis. And thirdly, the familiarity among participants in a same group might resemble better the type of good-will accounting, trust -or lack of it- and recognition that affects much of the decision making in social dilemmas of this and other kinds. The type of institutions that groups device for governing CPR dilemmas involve in many cases a history of previous interactions by members and a much higher probability of exchanges in the future than in the case of a group of students in most cases.

These factors mentioned, some may argue, could bring more noise and framing to the experiment than in a more controlled and cleaner lab experiment. Indeed they do. The proposition here is that such noise be used as data instead, and given that real world institutions and forms of governance form markets, states and communities do frame people every day, and that participants would find it rather difficult not to bring these into the lab, we might as well account for them and explain the variation in experimental behavior that the experimenter's institutions and environment can not.

Similar reflections about the power of using experiments and allowing participants in them to be part of the analysis hold for the student-teacher relation. Frank (1997) studied if participating or not in a simple classroom experiment made a difference in terms of academic performance by students taking a course where the tragedy of the commons is taught. His experimental design was simple and involving also a commons externality, where five participants had to decide between allocating one or five cows in a grazing pasture. Five cows was the dominant strategy which produced an inefficient outcome, and one cow induced the Pareto optimal solution. His comparison of a multiple choice test performance between those participating in the experiment, those only being present during the experiment, and those not exposed to it at all, showed that the latter group performed more poorly while the other two performed better and in fact with no statistical difference among them.

An experimental economics principles textbook by Bergstrom and Miller (1996) starts its Preface like this: *"Taking a course in experimental economics is a little like going to a dinner at a cannibal's house. Sometimes you will be the diner, sometimes you will be part of the dinner, sometimes both".* Not only can the active involvement in a experiment change the process of teaching with positive results like in Frank's experiments, but it can allow the relation teacher-student to be more creative to explore such a complex area of economics where there are still puzzles to be solved. Therefore, can one draw some methodological lessons for those interested in CPR dilemmas?

i. A lesson for those teaching and prescribing policies about CPR problems: Bringing the experimental tools to the class might prove effective to get students not only interested but more creative in the process of understanding why groups may or may not use common-pool resources in a sustainable way.

ii. A lesson for those studying the CPR problems using experimental tools: To bring the lab experiment to the field and learn from, and with, the main actors, the actual commons users who face in their daily life the decision to extract more or less fish, more or less firewood, and the decision to comply, redefine or create rules of self-governance for improving social outcomes.

In both cases the term *'participant'* rather than *'subject'* may explain the difference in approaches about experimental economics. People as subjects are mere sources of data, either because they respond to a survey or make choices in an experimental design. People as participants, get involved in the process and contribute from their own perspectives. There is a major and rather old area of debate in other social sciences about the value of participatory research, rapid rural appraisal and the like (Perez, 1989; Fals Borda, 1991). Economics has participated less in the debate and could benefit greatly from considering it. The examples and arguments given above could be an invitation to the profession.

6. References

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