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Heterogeneity, Distribution, and Cooperation in Common Property Resource Management

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Kanbur considers the role of group heterogeneity in the success or failure of common property resource management. He argues that cooperative agreements are less likely to come about when agents are highly heterogeneous along relevant dimensions — and existing agreements are more likely to break down as a group becomes more heterogeneous.

Kanbur crystallizes his argument in simple numerical examples and illustrates by reference to case studies on common property resource management — in particular, cases involving fisheries and irrigation systems. More work is needed to substantiate Kanbur's argument, but his analysis so far supports the argument that equity and efficiency complement rather than oppose each other.

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1. Introduction

In many settings around the world, natural resources are managed under regimes that can be described neither as private property nor as state control. In the absence of ready classification into such easily recognizable regimes, it may be tempting, and it has been tempting for some, to classify these settings as falling into a single residual category. This category has been labelled interchangeably as "common property" or "open access". However, the burden of a recently developed literature is that open access (res nullius) is different from common property (res communes), both conceptually and in practice. The residual from private property and state property is thus not one category but two. This literature argues that the lack of a distinction has led not only to considerable conceptual confusion, but disastrous policy failure as well.

The problems of open access were dramatized by Hardin (1968) in his famous "Tragedy of the Commons", where he portrays the negative externality that each herder imposes on others as he adds extra animals to a pasture open to all. Clearly, the final outcome of this process, the non cooperative equilibrium, is inefficient--overgrazing occurs and "freedom in the commons brings ruin to all." The solution to the tragedy, according to Hardin, was either private property rights or state control.

Hardin's metaphor has become exceedingly influential in the debate on natural resource management. All the more unfortunate, then, as Bromley (1991) notes in his incisive critique, that "it would be difficult to find an *idea* (a concept) that is as misunderstood as that of the *commons* and *common property*". Early critiques of the Hardin thesis are to be found in Dasgupta and Heal (1979) and Dasgupta (1982). According to Bromley (1991), Gardner, Ostrom and Walker (1990), and Dasgupta and Maler (1991), the crucial distinction to be made is that between the physical properties of a resource and the institutional mechanisms in place for managing it. Many natural resources have the characteristics that while the exploitation of the resource by one agent has a negative effect on other agents (subtractability) it is costly to prevent such exploitation (non-excludability). The "commons" in Hardin's allegory have these characteristics. But these properties are to be distinguished from the management mechanisms to deal with the problems to which they give rise.

One management mechanism is simply that of no management. This is what leads to "open access" and the outcome is the inefficient non-cooperative equilibrium--the "tragedy." Two other mechanisms are private property and state control. But there is a fourth mechanism, that of *common property* which, until recently, slipped through the analytical net. This is the case where the natural resource is managed by a communal group that devises and enforces control of e[illegible]oitation of the resource. As Bromley (1991) notes, there are plenty of examples of this mechanism:

"The European common fields, the common forests (Iriachi) in Japan, the common pastures in the Himalayas and the Andes, and the Summer pastures in the Swiss Alps are examples of common property resources that were (and still are) certainly not open to all for indiscriminate squandering. Despite sweeping predictions..., these common property natural resources have been well managed for thousands of years. They are not mismanaged *precisely* because they are common property resources."

Numerous other examples of common property regimes are given, for example, in Ostrom (1990), Feeny et-al (1990) and National Research Council (1986). The tragedy of the commons is not therefore, the tragedy of common property management. It is a tragedy of open access. It is argued by some that the confusion has cost dear. Analysts and policy makers saw uncontrolled exploitation where in fact there existed indigenous institutions based on common property. They rushed to substitute state control for what they perceived to be no control. In the process, they ended up destroying the common property mechanisms that did exist. This might not have been so bad if state control had indeed worked. But in many cases it did not, and a common property regime was effectively converted to open access, leading to an even worse degradation of the natural resource (Cordell and McKean, 1986; Messerschmidt, 1986). This misconception followed by policy failure might in fact be called the real tragedy of the commons.

The last decade has seen an upsurge of research interest in common property resource management mechanisms. Detailed case studies of how externalities are managed in groups exploiting natural resources have led to greater understanding of the mechanisms. In her important overview, Ostrom (1990) has attempted to synthesize the literature and highlight certain "design principles" that lead to success. These include, for example, clear group boundaries and memberships, effective monitoring, and conflict resolution mechanisms. But an important conclusion from some of the case studies is that common property regimes do break down, and for reasons that have nothing to do with wanton or misguided state intervention. Changes in the economic environment sometimes put an intolerable strain on the cooperative mechanisms in place, and the common property regime crumbles.

There are many types of changes in the environment that can lead to a breakdown of cooperative agreements. One obvious example is an increase in group size through natural population increase. As group size increases monitoring becomes less effective. However, in this paper I want to focus on one particular tension in cooperative agreements - the conflict that arises because of heterogeneity within the group, and the heightening of this conflict as a result of external changes in the economic environment.

The basic argument I want to make is intuitively straightforward. In the presence of an externality, a non-cooperative equilibrium will be inefficient. By this, it is meant that there exists an assignment of actions to each agent such that, if they all adhere to the agreement, the group as a whole will be better off--the sum of the individual payoffs will be greater than the corresponding sum in the non-cooperative setting. If all agents are identical, then the cooperative agreement will entail identical assignment of actions, and an identical increase in each agent's payoff. The only question now is enforcing the agreement, since any single agent could get an even bigger increase in payoff by breaking the agreement if no one else does.

Let us assume that the agreement can be enforced--the recent literature examines the mechanisms whereby this is achieved. But suppose now that the agents are not identical--their payoff functions differ. There will still be an assignment of actions to each agent which will maximize the sum of the payoffs. But now the increment relative to the non-cooperative outcome will differ across individuals. Indeed, for some individuals there might not be an increment at all - the payoff when the individual undertakes the action assigned to him in the cooperative agreement may well be less than his non-cooperative payoff. Why then should this individual agree to cooperate?

The answer given by the literature is that there are side payments. Compensation will ensure that no individual is worse off by cooperating. Beyond this, there is the issue of the distribution of gains from cooperation when individuals are not identical. Various answers are available in the theoretical literature. For example, "Nash bargain" arguments could be used to relate the distribution to individual payoffs if cooperation did not succeed. The potential non-cooperative outcome could, therefore, influence the distributional consequences of cooperation. But if side payments are possible and costless, then all that heterogeneity in the group will do is to determine the distribution of gains from cooperation - it will not influence whether or not cooperation takes place.

In a series of conceptual and empirical studies, Libecap and associates have argued that side payments throw up as many difficulties as the monitoring of action in cooperative agreements, if not more (for a summary, see Libecap, 1989). Their premise is that while side payment mechanisms do exist they are at best incomplete. Thus, cooperation that leads to Pareto improvements without side payments is most likely to succeed. Following on from this, is the thought that "inherent heterogeneity" in the group is thus an important determinant of whether or not cooperation will take place. Johnson and Libecap (1982) have put forward this idea, and applied it to fisheries where fishermen differ in their inherent skills in fishing. The argument, substantiated by case studies, is that cooperative agreements such as catch restrictions are unlikely to succeed.

Building on this line of inquiry, this paper considers the consequences of increased within group heterogeneity for the sustainability of cooperative agreements. As might be expected from the above, it is argued that certain economic developments, that lead to greatly increased divergence in the value that individuals put on a natural resource, are likely to lead to a break down of cooperation and a reversion to the non-cooperative outcome, even when there has been no deterioration in the effectiveness of monitoring or enforcement of actions.

The next section sets out a simple numerical example that crystallizes these concerns. Section 3 considers a number of case studies that illustrate the forces identified here. Section 4 concludes the paper.

2. A Numerical Example

Consider two individuals, indexed 1 and 2, choosing actions y_1 and y_2 that give payoffs R_1 and R_2 as follows:

(1) $$R_1 = a_1 y_1 - \tfrac{1}{2} y_1^2 - \tfrac{1}{2} (y_1 + y_2)^2$$

(2) $$R_2 = a_2 y_2 - \tfrac{1}{2} y_2^2 - \tfrac{1}{2} (y_1 + y_2)^2$$

The payoff functions embody a negative externality, in that each individual's action affects the payoffs of the other individual adversely. They also contain an asymmetry in the parameters a_1 and a_2--the marginal value of the action differs between the two individuals. The model can be interpreted as representing the exploitation of a natural resource where private benefits are a_i y_i and private costs are $\tfrac{1}{2}$ y_i^2, but there is a common social cost that depends on joint exploitation, and is given by $\tfrac{1}{2}$ $(y_1 + y_2)^2$.

The simple structure allows for an explicit solution of the Nash equibilrium. The reaction functions of the two individuals are:

$$(3)\qquad y_1 = \tfrac{1}{2} a_1 - \tfrac{1}{2} y_2$$

$$(4)\qquad y_2 = \tfrac{1}{2} a_2 - \tfrac{1}{2} y_1$$

The Nash equilibrium values of y_i, superscripted by N, are thus:

$$(5)\qquad y_1^N = {}^2/_3\, a_1 - {}^1/_3\, a_2$$

$$(6)\qquad y_2^N = {}^2/_3\, a_2 - {}^1/_3\, a_1$$

and the respective payoffs are:

$$(7)\qquad R_1^N = {}^1/_{18}\, [7a_1^2 - 4a_1a_2 - 2a_2^2]$$

$$(8)\qquad R_2^N = {}^1/_{18}\, [7a_2^2 - 4a_1a_2 - 2a_1^2]$$

The total level of resource exploitation and payoff is given by:

$$(9)\qquad y^N = y_1^N + y_2^N = {}^1/_3\, (a_1 + a_2)$$

$$(10)\qquad R^N = R_1^N + R_2^N = {}^1/_{18}[5a_1^2 - 8a_1a_2 + 5a_2^2]$$

The cooperative outcome maximizes the sum of the payoffs by choice of y_1 and y_2, and leads to the solutions y_i^C:

(11) $y_1^C = {}^3/_8 a_1 - {}^1/_8 a_2$

(12) $y_2^C = {}^3/_8 a_2 - {}^1/_8 a_1$

With these values of the control variables, and no side-payments, the individual payoffs are given by:

(13) $R_1^C = {}^1/_{128}\,(35a_1^2 - 18a_1a_2 - 5a_2^2)$

(14) $R_2^C = {}^1/_{128}\,(35a_2^2 - 18a_1a_2 - 5a_1^2)$

The total level of resource exploitation and payoff is thus:

(15) $y^C = y_1^C + y_2^C = \frac{1}{4}(a_1 + a_2)$

(16) $R^C = R_1^C + R_2^C = {}^3/_{64}\,[5a_1^2 - 6a_1a_2 + 5a_2^2]$

The objective of the exercise is to see how the different payoffs relate to one another as the dispersion between a_1 and a_2 increases. We will do this by focussing on the value of $a_1/a_2 = \alpha$. Restricting attention to positive values of a_1 and a_2, and requiring y_1 and y_2 to be positive,

(17) $2 > \alpha > \frac{1}{2}$

by reference to (5) and (6). Comparing R^N and R^C from (10) and (16), a simple calculation shows that $R^C > R^N$, which is as it should be--cooperation pays. From (9) and (10), it is clear that cooperation pays because it restricts total exploitation. But from (5), (6), (11) and (12) it is seen that the extent of restriction differs:

(18) $y_1^N - y_1^C = {}^1/_{24}\,(7a_1 - 5a_2)$

(19) $y_2^N - y_1^C = {}^1/_{24}\,(7a_2 - 5a_1)$

Both individuals' exploitation will be restricted only if:

(20) ${}^7/_5 > \alpha > {}^5/_7$

Outside this range (but consistent with (17)) cooperation requires one individual to restrict exploitation and the other to intensify exploitation relative to the Nash equilibrium.

The above hints at a possible distributional conflict, and the key is whether or not side payments are possible. If they are we can appeal to the axioms of Nash bargaining theory, and use R_1^N and R_2^N as threat points. The Nash bargained payoffs resulting from cooperation are then:

(21) $R_1^B = ½(R_1^N - R_2^N) + ½\, R^C$

(22) $R_2^B = ½(R_2^N - R_1^N) + ½\, R^C$

Since $R^C > R^N = R_1^N + R_2^N$, it follows that $R_1^B > R_1^N$ and $R_2^B > R_2^N$. This is only to confirm that with side payments the cooperative outcome ensures a Pareto improvement.

But what if side payment mechanisms are incomplete? For sharpness, let us suppose they are non-existent. Then individual i will only agree to the actions (y_1^C, y_2^C) if $R_i^C > R_i^N$. Without loss of generality let us consider individual 1. It can be shown from (7) and (13) that:

(23) $R_1^C - R_1^N = (a_2^2/(128x18))\,[-266(\alpha)^2 + 188\,(\alpha) + 166]$

The sign of this depends on

(24) $\triangle_1 = -266\,\alpha^2 + 188\alpha + 166$

where α is restricted to lie between ½ and 2.

Figure 1 sketches $\triangle_1$ as a function of α. It is seen that when $\alpha = 1$, $\triangle_1 > 0$, but as the disparity between a_1 and a_2 grows, there comes a point where the cooperative agreement is no longer beneficial to individual 1. When $\alpha > 1.2$, $\triangle_1 < 0$. By symmetry, when $\alpha < (^1/_{1.2}) = 0.83$, $\triangle_2 < 0$. Thus if:

(25) $0.83 < \alpha < 1.2$

then both individuals benefit from the jointly maximizing patterns of resource optimization. Outside this range, however, one or the other of the individuals loses.

Finally, notice from (23) how the benefits from cooperation change as <u>both</u> a_1 and a_2 increase. It should be clear that there is a close link between heterogeneity and the effect of an overall increase in the value of the resource. If α is such that $R_i^C - R_i^N > 0$, then an equiproportionate increase in a_1 and a_2 will increase even further the gains to both parties from cooperation. However, if a_1 and a_2 are so disparate that one party loses from cooperation, then an equi-proportionate increase in a_1 and a_2 will further increases losses to this party from cooperation. Thus once again, the extent of heterogeneity matters.

The above example suffices to illustrate the basic intuition that greater heterogeneity makes it more and more difficult to ensure that the jointly optimal allocation of actions is a Pareto improvement. Of course, this tension will be relieved to the extent that: (i) side payments are possible or (ii) we do not ask for the attainment of the full joint optimum. However, the latter means that there is less surplus to finance the costs of policing the cooperative agreement, while the former is also not without costs - it requires the presence of related institutional arrangements that act as "conduits" for the side payments (Libecap, 1989; Furu ͻotn, 1989). It is seen form (24) that the more disparate are the two individuals, the greater will be the amount of side payment to be funnelled through these institutional devices. Even if present institutional arrangements suffice for the side payments required, they may not be adequate for a vastly increased need for side payments, occasioned by greater heterogeneity. This may in turn be caused by a change in the external environmen: which increases the value of the natural resource disproportionately to a subset of the group. The next section will examine various case studies to see if this dynamic is present i.. practice.

3. Selected Case Studies of Common Property Resource Management

3.1 The Case Study Literature

While there have been some limited attempts to analyze common property resource management through econometric techniques based on a large number of observations (see Migot-Adholla et-al, 1991), the dominant form of empirical investigation of this phenomenon is the case study method. This is not surprising, since identification of monitoring and enforcement mechanisms, for example, require a detailed knowledge of, and ability to interpret, localized and specific behavior. Participant observation seems necessary, requiring the build up of trust between the investigator and those being investigated. On the other hand, case study evidence always raises the issue of isolated occurrence versus generalizable findings. To overcome this, Ostrom (1990) and associates have been attempting to systematically code various dimensions of individual case studies. The task is made difficult by the fact that many, if not most, studies were undertaken not necessarily to elucidate the mechanisms of common property resource management. A study might have been conducted, for example, to highlight aspects of symbolic anthropology--and it takes a certain interpretation and interpolation to weave together the observations in the case study into a coherent picture of resource management. In these situations we are often twice removed from the basic phenomenon--relying firstly on the interpretations of the participant observers and secondly on the interpretations of the case study oriented common property analyst.

However, despite these caveats, a formidable consolidation of case studies has been taking place in the last few years. Martin (1989) is a recent bibliography, and Ostrom (1990) describes a project to systematize the findings of case studies. Schlager (1990) and Tang (1989) show the insights that can be gained from comparing groups of case studies restricted to particular resources: fisheries, or irrigation, for example. The compilation of case studies in the National Research Council (1986) speaks directly to resource management. In what follows I use the information revealed by these studies selectively to demonstrate the importance of heterogeneity as a determinant of the sustainability of common property regimes. Of course, it goes without saying that I will not highlight other aspects--for example, the details of monitoring and enforcement mechanisms as emphasized by Ostrom (1990).

3.2 Schlager (1990): 30 Case Studies of Fisheries

Schlager (1990) attempts to systematize the findings of thirty chosen case studies of fishery management from around the world- eleven in Central and South America, eight in North America, seven in Asia, and four in Europe. The documentation for the case studies is examined in detail and in-depth coding procedures are followed for each study, recording the decision makin~ rules, conflict resolution mechanisms, the stakes of the participants, the boundaries and physical characteristics of the resource, etc.

Schlager's (1990) analysis reveals some fascinating and important correlations. For example, she finds that the existence of "assignment externalities" (i.e. where there is conflict over a limited number of choice fishing spots) is significantly related, in her 30 case studies, to whether or not fisherman have an organized method of harvesting fish. Similarly, "technological externalities" (caused by different types of fishing gear) also increases the chances of organized fishing.

Schlager's (1990) analysis does not have a particularly strong focus on the main concern of this paper - group heterogeneity. But some of her generalizations are suggestive:

"Among the thirty-three sub-groups who have organized their harvesting activities, and for which there is information, twenty-six, or 84%, operate within a stable economic environment, whereas among the eleven subgroups who have not organized institutional arrangements, five, or 50% operate within a stable economic environment."

"Among the sub-groups that have engaged in institutional design, for which there is information, 68% or 13, would receive moderate to high returns for additional units of fish, and 32% or 6 subgroups would receive low returns for additional units of fish harvested. Among the subgroups that have not organized, and for which there is information, 87% or 7 subgroups would receive high to moderate returns and 1 would receive low returns."

These observations can be argued to be supportive of the general directions hinted at in the numerical example of the previous section. They cannot of course be conclusive. As we shall see, the same is true of a study of collective action in irrigation systems.

3.3 Tang (1992): 47 Case Studies of Irrigation Systems

Tang (1992) presents a synthesis based on a careful analysis of 47 case studies of irrigation systems (see also Tang, 1991). Like Schlager (1990), Tang derives a number of important generalizations on performance of the systems in relation to management mechanisms employed. Once again, group heterogeneity is not a major focus of the analysis, but Tang has more to say on this issue than Schlager. For example, on the distribution of the gains from cooperation, Tang (1992) notes:

"Some commentators are concerned that indigenous organizations tend to perpetuate inequalities among farmers. They argue that the decision-making processes in many of these communities are dominated by the elite in the communities. The poor and less influential farmers are usually disadvantaged in their access to common pool resources in the communities. An examination of the sample, however, does not support this contention. Only four out of the 23 community irrigation systems in the sample are characterized by institutional arrangements that are specifically designed to favor one or more group of irrigators over another".

More to the point of this paper, Tang (1992) asks: "What is the variance of the average annual income across families among appropriators?" The answer is suggestive, and supportive of the line taken in this paper:

"In the sample of cases, a low variance of the average annual family income among irrigators tends to be associated with a high degree of rule conformance and good maintenance: seventy-two percent more of the cases with low-income variance are characterized by both a high degree of rule conformance and good maintenance than of the cases with high income variance."

This second conclusion may throw new light on the first--successful schemes are to be found in relatively homogeneous communities, and it is precisely in these communities that one is unlikely to find arrangements that favor one sub-group over another. Tang (1992) cautions the reader on these conclusions, since they are based only on a subset of cases that provided enough information "for us to estimate roughly the degree of income variance among the irrigators." Also, of course, there are multiple determinants of success or failure. Finally, and this is also true of the Schlager (1990) overview, there is little discussion of whether or not there are side payments to relieve the tensions of cooperation with heterogeneity. For this one must look to individual case studies, and it is to these that we now turn.

3.4 Cordell and McKean (1986): Fishing in Bahia, Brazil

Cordell and McKean (1986) present an extremely informative, in-depth, ethnographic study of sea tenure, which is defined as "collectively managed informal territorial use rights in a range of fisheries previously regarded as unownable". The field work relates to the Bahian coastline in Brazil:

"Fishermen on the southern Bahian Coast still work mainly from sail canoes, using customary lines, nets, traps, and corrals to harvest more than 200 different species of fish and shellfish. They lay claim to extensive fishing grounds in the 1,000 kilometer strip of shallow waters between Salvador and the Abrothos Banks."

Given that fishing spots differ in attractiveness, and the scope for conflict over these spots and over gear interference, there is scope for cooperative agreements that establish, and enforce, fishing rights. Cordell and McKean (1986) provide a detailed account of the local mechanisms for monitoring and enforcing these rights, and show how they are intimately connected to local customs and mores, relying on an ethical code of respeito (respect). For example, conflict resolution requires that mediators be found who are accorded due respect by all parties ("They are usually retired fishing captains, or in some cases fishermen's widows.")

The case study also reveals practices that can be interpreted as side payment mechanisms. A good catch leads to the bestowing of fish on others, and the "holding of beer-drinking fests. A bar floor littered with beer bottles at dawn is a sure sign that a fishing captain has been celebrating great good fortune and skill: empty beer bottles are valued storage containers in swamp-fishing neighborhoods, and to break them is considered extravagant." Cordell and McKean (1986) further detail the role of "godparenthood networks" and the reciprocity that they entail between access to fishing rights and godparenting.

The picture one has, therefore, is of a system of sea tenure as a cooperative outcome maintained by local sanctions and side payment mechanisms. Cordell and McKean (1986) go on, however, to discuss the breakdown of these arrangements as a result of external influences:

"All that is required to shatter the balance is for an external power to assert domain--- or for a local enclave to begin using competitive technology .... At that point, the internal code among local fishermen loses its own raison d' être and breaks down since there is no longer anything for the local fishermen to gain through cooperative fishing. Such encroachment by inappropriate gear and nonresident boats began in the early 1970s, when nylon nets started to compete with traditional gear for identical species and water space ... hundreds of monofilament nylon gill nets and seines were introduced by the fisheries agency (SUDEPE) which provided loans and tax incentives for investors. This rivalry has altered the distribution of equipment in Valenca and the concentration of ownership in the different categories represented. As a result of encroachment, rich nursery-area fisheries have been gravely damaged, and short-term speculation and overcapitalization have led to sudden overfishing of a number of native estuarine and reef species."

The above account is highly suggestive of how external changes led to divergent interests among local fishermen. The existing institutions, including side payment mechanisms, were clearly not sufficient to prevent the breakdown of long-standing cooperation

3.5 Alexander (1982) and Ostrom (1990): A Sri Lankan Fishery

Ostrom (1990) relies on Alexander's (1982) study of the fishing village of Mawelle in Sri Lanka to analyze the breakdown of cooperative agreements. In what follows I rely on Ostrom's account. She describes the net sequencing procedures drawn up among beach seines in the village, in response to assignment and technological externalities. But demographic pressures and external changes in the economic environment led to a dramatic deterioration in cooperation. Of particular importance to us is Ostrom's observation that:

"During the early 1940s, the construction of a new road linking Mawelle to marketing centers, the constructing of an ice factory nearby, and the marketing efforts of the Fish Sales Union greatly increased the demand for and market value of fresh fish. Prices for fish increased four-fold between 1938 and 1941 (Alexander 1982, p. 210). Then the pressure to introduce new nets really gained momentum... New entrepreneurs began to buy shares in more than one net and to hire wage laborers to work their shares. Thus, the ownership patterns were shifting at the same time that the number of nets was greatly increasing. By 1971, many of the owners were not members of the same kinship group, owned shares in multiple nets, and hired wage laborers to work their share. Further, the heads of several factions in the village purchased shares both for the economic returns they could obtain and as a means of providing work for their loyal followers."

I would argue that the above account is highly suggestive of a dramatic interaction between an increase in the value of the resource under consideration, and pre-existing and new heterogeneities in the village. This interaction led to an increasingly divergent set of interests and accounts at least partly for the breakdown in cooperation.

3.6 Johnson and Libecap (1982): North American Fisheries

As noted in Section 1, a series of papers by Libecap and associates have paid the most explicit attention to heterogeneity and cooperation. Johnson and Libecap (1982) present an analysis for several fisheries in North America, paying particular attention to the Texas shrimp industry. This industry is considered over capitalized, and the question is why cooperative mechanisms for catch restriction have not developed. The answer provided by Johnson and Libecap (1982) is that:

"Contracting costs are high among heterogeneous fishermen, who vary principally with regard to fishing skill. The differential yields that result from heterogeneity affect the willingness to organize with others for specific regulations.... Indeed, if fishermen had equal abilities and yields, the net gains from effort controls would be evenly spread, and given the large estimates of rent dissipation in many fisheries, rules governing effort or catch would be quickly adopted.... For example, total effort could be restricted through uniform quotas for eligible fishermen. But if fishermen are heterogeneous, uniform quotas will be costly to assign and enforce because of opposition from more productive fishermen. Without side payments (which are difficult to administer), uniform quotas could leave more productive fishermen worse off."

Their institutional-empirical analysis of various failures in regulating the Texas Shrimp fishery confirms the above argument.

3.7 Wade (1986): Management of Irrigation in South India

Wade's (1986) account of resource management in South Indian villages provides an interesting account of irrigation and water control management. The basic problem is that up stream farmers are better placed than those downstream, since the former can in principle use a lot of water and leave very little to flow to the latter. In the villages studied, Wade found that irrigators are hired to allocate water. Many aspects of this arrangement are analyzed, including supplemental monitoring and sanctioning mechanisms, and how the irrigators are paid for:

"Of course, if the power structure of the village were such that no collective action could be sustained without the agreement of a small number of households, and if these households held all their land close to the irrigation channel, then they would have no interest in rules of access. In practice, however, holdings are typically scattered about the village area in small parcels, partly to diffuse risk and partly because of inheritance practices: a landowner with a plot close to one irrigation outlet may have another plot close to the tail-end of a block fed from another outlet. This greatly helps the consensus on the need for rules and joint regulation."

Wade's analysis reveals an interesting dimension of the heterogeneity/homogeneity issue. While the landowners are undoubtedly not identical, the very fact that they have scattered plots engenders uniformity of interest in irrigation agreements. Here, consolidation of the fragmented parcels (which some might argue for an the grounds of productive efficiency) may well lead to divergent interests and breakdown of cooperation.

3.8 Harriss (1977) and Ostrom (1990): Management of Irrigation in Sri Lanka

In contrast to Wade's (1986) account of successful irrigation management, we have Ostrom's (1990) account of the failure of irrigation management in certain projects in Sri Lanka. Using the work of Harriss (1977) in Kirindi Oya, Ostrom documents and analyses the factors underlying this failure. These include the large number of farmers involved and technical aspects of the irrigation system, but Ostrom highlights the role of ethnic heterogeneity, and also the role of wealthy farmers in controlling water by influencing officials:

"Large landowners frequently captured the major positions on some of the cultivation Committees for Kirindi Oya and obtained special privileges related to water distribution through internal influence or by seeking external political intervention. None of the participants in the Kirindi Oya project is motivated to do anything but follow dominant strategies. For the individual farmers, the only reasonable strategy to follow in a system in which others steal water with impunity ..... is to flood their own fields as much as possible, using whatever means are necessary to do so. For the large landowners, keeping active political contacts with national leaders is one method of ensuring some protection for illegal practices."

The contrast with Wade's (1986) villages could not be greater. While there are of course many differences between the two cases, from our perspective what is important is the disproportionately large return to big landowners from extra water in the Sri Lankan case. In the South Indian case there was also inequality of landholding, but fragmentation of holdings vis a vis the irrigation channel led to a "homogenization" of the returns from cooperation when compared to the non-cooperative outcome.

3.9 Coward (1979) and Tang (1992): Irrigation in the Philippines

As a final example, consider Tang's (1992) account, drawn from Coward's (1979) study of irrigation management in Zanjera Danum in the Philippines, which again shows how physical characteristics of a system - whether historically developed or institutionally chosen -

can deliver sufficient homogeneity of interests to allow successful cooperation:

"In some community irrigation systems, irrigators' associations specifically adopt rules to ensure that members have fields in the lead, middle and tail portions of the major canals. For instance, within each watercourse in Zanjera Danum in the Philippines, land along a lateral canal is divided into several blocks perpendicular to the source of water (Coward, 1979). The blocks thus represent differential distance from the water source: some are near the head of the canal, some near the tailend. Each of the blocks is further divided into several parcels. Each share in the irrigation system is tied to one parcel in each block, so that each share holder has to cultivate parcels of various distances from the water source. This arrangement creates an interest among all irrigators to help deliver water throughout the entire watercourse."

4. Conclusion: Equity versus Efficiency Revisited

The general line of argument developed in the introduction, and illustrated by numerical simulation and by case studies in the following sections, speaks to the age old question of the relationship between equity and efficiency. If the argument has credence, it suggests that greater equity (at least, greater homogeneity) promotes greater efficiency by facilitating the adoption of cooperative agreements, in situations where externalities make non-cooperative outcomes inefficient.

Of course, in developing the argument in its sharpest from, I have assumed no side payments. But side payment mechanisms are not without cost, and their non-existence or incompleteness in practice may be perfectly explicable in these terms (Furubotn 1989). Given this incompleteness, however, theory and evidence would seem to suggest that cooperative agreements are more likely to come about in groups that are homogeneous in the relevant economic dimension, and they are more likely to break down as heterogeneity along this dimension increases. In terms of the numerical example of section 2, compare the situation where $a_1 = {}^2/_3$, $a_2 = {}^1/_3$ with that where $a_1 = ½$, $a_2 = ½$. From (25) we know that cooperation will not occur in the former case but it will in the latter. In the first case the sum of individual non-cooperative pay offs is given by (10), as ${}^1/_{18}$. In the second case the joint payoff is given by (16), as 0.22, which is clearly superior.

Equalizing a_1 and a_2 promotes efficiency, as well as equity of course. The design of the Zanjera Danum irrigation system in the Philippines, discussed in section 3.9, is an illustration of this principle. Disequalization of a_1 and a_2 leads not only to greater inequality, but may precipitate a break down of cooperation. The disintegration of agreements in the fishing village of Mawelle in Sri Lanka (section 3.5), with resultant over fishing, illustrates this other side of the coin.

Clearly, more work is needed to further substantiate the argument advanced here. At the theoretical level, the numerical example needs to be generalized (Kanbur and Keen, in preparation). At the case study level, a more thorough trawl through existing case studies is required, to identify more specific aspects of distribution and side payments. New case studies, designed specifically to answer the questions posed here, are also needed. In the meantime there is, prima facie, an additional argument for the complementarity between equity and efficiency.

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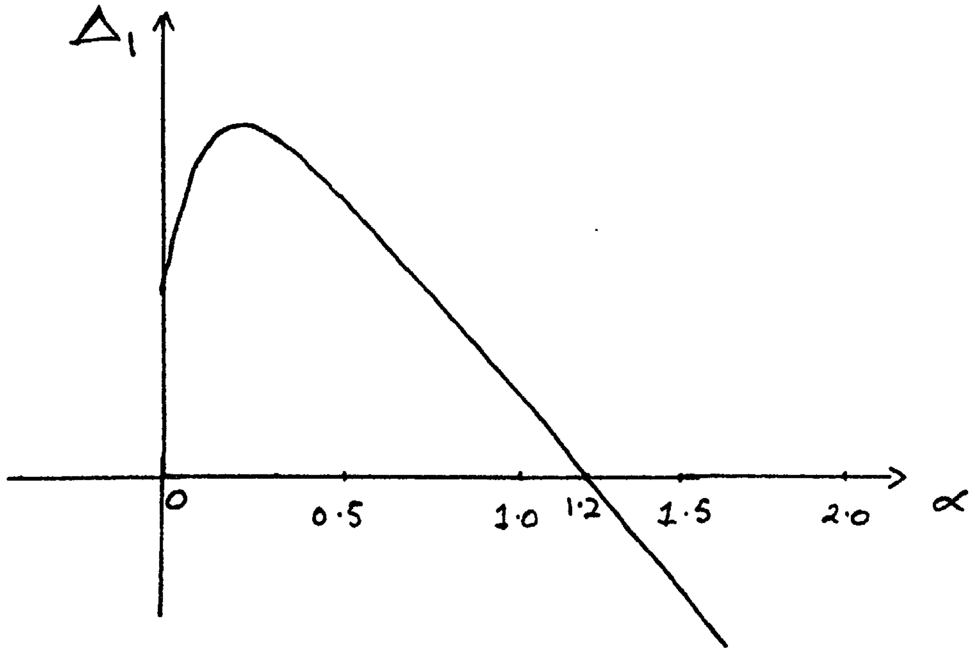

Figure 1

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