A Partnership Solution to the Tragedy of the Commons

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I. Introduction

The fundamental result of the problem of the commons was identified by Dasgupta and Heal (1979) which demonstrated that the effort supplied in the extraction of a common property resource depends on the number of resource users. One user would supply the socially optimal effort level while a sufficiently large number of harvesters would supply effort until its average product rather than its marginal product would be equal to the opportunity cost of effort. This result suggests several management institutions that could generate the socially optimal outcome for a limited access common property resource.

Cooperative management or state ownership is one alternative since a sole owner would not face the problem of the commons. Due to the lack of private incentives, however, state or cooperative management and ownership of common property resources requires the monitoring of individual harvesters (for state ownership) or faces the challenges of the labour managed firm for cooperatives (Sen, 1966, Ireland and Meade, 1982). State ownership and management of common property resources induces individual harvesters to shirk or to supply less than the socially optimal amount of effort because harvesters are not allowed to retain their entire output. in many industrialised countries the distribution of user rights in the form of individual quotas has become a popular management regime (particularly for fisheries) in which the state or a government agency announces a total allowable catch and determines how it is distributed among users. Individual quota management, however, relies on accurate stock estimation and provides incentives to harvest as much as legally possible because resource users are unsure about the total allowable catch and stock size that will be available to them in the future. Harvesters therefore try to exhaust their quota (unless quota banking is possible) and try to achieve the highest possible value for their quota which could lead to high-grading problems (see Copes, 1986). This is particularly problematic if the government agency overestimated stock size (as in some years in the Northern cod fishery) and if there are differently valued grades of the resource (such as age classes for fish). Individual quota management furthermore requires the transition of common property rights to private property rights which often is encountered with criticism and resistance by harvesters (as for example in Newfoundland's inshore fishery).

Due to the above-mentioned problems with the separation of ownership and control from the harvest of a common property resource it seems advantageous to provide resource users with more control and long-term ownership over the resource. Common property ownership and management is therefore receiving increasingly greater attention (for example in the form of community ownership and management, see Bromley, 1992, Ostrom, 1990, Ostrom et al., 1994 or in the form of co-management between communities and a government agency, Pinkerton, 1994). One major advantage of community-based management regimes is that information about harvesting activities tends to be widely shared and mutually monitored by community members (Pinkerton, 1994). Proper incentives and the consideration of community boundaries or authority rules, however, are essential in a regime where resource users have direct control over the future harvest of the resource. The appropriate incentive mechanism for a noncooperative common property management regime has not been explored and is the subject of this paper. The developed model provides a solution to fundamental problems of common property resources without the necessity of changing property rights.

This paper introduces a management regime that would maintain common property rights by allowing resource users to harvest on their own but to share their extraction outcome with a given number of other resource users. The developed partnership approach makes use of the shirking incentives in output sharing partnerships to counterbalance the incentive to supply excessive effort that prevails in noncooperative common property extraction. A first-best solution is derived and the socially optimal partnership size and number of partnerships for a fixed number of harvesters is determined for different conjectural variations. The results provide a new interpretation of conjectural variations in the supply of harvesting effort as it establishes some links to community boundaries, social capital and resource characteristics. The implication of community boundaries and authority systems as well as resource boundaries on proper sharing arrangements is explored in various applications of the partnership solution that can consist of randomly assigning resource users to teams after every harvesting round, having the same team members for several rounds or joining community members in partnerships.

II. Common Property Resource Extraction and the "Tragedy of the Commons"

The "tragedy of the commons" was first recognized by Hardin (1968) in an application to the situation of several herdsmen using a common grazing area. Hardin points out that the marginal benefit of adding an animal for each herdsman is greater than the marginal cost because the cost is shared by all herdsmen. Free access to the commons therefore "...brings ruin to all" (Hardin, 1968) as it leads to an overexploitation of a scarce resource, in which the average product of the variable input, not its marginal product, is equated to the input's rental rate (Sandier, 1992). Each producer or harvester imposes an external cost on rivals that can be both static and dynamic in nature (Brown, 1974). The former reflects the opportunity cost of congestion while the latter reflects the scarcity value of the resource (Brown, 1974). Static externalities represent a "crowding problem" while dynamic externalities exist if current actions lead to higher future costs. This paper focusses on the classic static externality problem.

The static common property externality has been analysed by Dasgupta & Heal (1979) and by Sandler(1992) who specify a model with a fixed number of harvesters that can choose the number of vessels that they wish to employ. Because fishing vessel number and size restrictions have not been able to avoid excessive harvesting and excessive fishing capacity augmentations (as for example in Atlantic Canada's and the Alaskan fishery), total effort rather than vessel numbers are utilized here. Each of the 'N' licensed resource users supplies 'e' units of effort. Total effort supplied ('E') therefore equals eN=E. Total production output ('Y') for a fixed (steady state) common property resource size then solely depends on total effort:

$$Y=Q(E) \qquad (1)$$

It is assumed that the market price for the harvested resource is exogenously fixed at unity and harvesters have an opportunity cost of effort equal to 'w'.[1] Each harvesters catch ('y') then equals its share of total effort times total production:

$$y=\frac{e}{e+\tilde{E}}Q(e+\tilde{E}) \qquad (2)$$

where $\tilde{E}$ =total effort supplied by everyone else.

Resource users wish to maximize profit:

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[1] A fixed market price for fish is a valid assumption for many species that are processed, frozen and sold on a competitive world market.

$$\max_{e} \frac{e}{e+\widetilde{E}} Q(e+\widetilde{E}) - we \qquad (3)$$

resulting in the following first-order conditions for each harvester:

$$\frac{e+\widetilde{E}-e(1+\frac{\partial \widetilde{E}}{\partial e})}{E} \frac{Q(E)}{E} + \frac{e}{E} Q_E (1+\frac{\partial \widetilde{E}}{\partial e}) - w = 0 \qquad (4)$$

The supply of effort depends partly on the expectation of harvesters about the impact of their supply of effort on the quantity of effort supplied by all other resources users ($\frac{\partial \widetilde{E}}{\partial e}$). A first-best solution can be derived by choosing a total effort level that maximizes the difference between total revenue and total cost from the harvest of the resource:

$$\max_{E} Q(E) - wE \ . \qquad (5)$$

The socially optimal condition therefore consists of supplying effort until the marginal product of effort equals its opportunity cost or Q_E=w. Harvesters only supply the socially optimal amount of effort if either $\frac{\partial \widetilde{E}}{\partial e}$=N-1 or if N=1. In other words a socially optimal result is achieved if harvesters either anticipate that their supply of effort affects the action of all other harvesters or if there is a sole owner (see Scott, 1955). The fundamental problem of the commons (Dasgupta and Heal, 1979) occurs if resource users take the action of other harvesters as given when making their own effort decision. In the latter case $\frac{\partial \widetilde{E}}{\partial e}$=0 and the symmetric Nash equilibrium results in:

$$\frac{N-1}{N} \frac{Q(E)}{E} + \frac{1}{N} Q_E = w \cdot \qquad (6)$$

A sole owner would still harvest in a socially optimal manner but even as many as two harvesters would not. As N approaches infinity effort is supplied until its average product and not its marginal product is equal to its opportunity cost. This tragedy of the commons result has inspired management solutions based on a social planner that maximizes the rent form harvesting the resource by either harvesting with its own fleet (as in some communist or ex-communist countries) or by setting a total allowable catch and establishing private rights to the annual extraction from the common property resource. If the owners of the resource are not involved in the harvesting activity, they need to monitor fishing effort or proper use of fishing rights. Communities that own and harvest common property or cooperatives have the advantage that the owners are simultaneously harvesters and therefore have insider information about harvesting procedures and a vested interest in the sustainable use of the resource. Community ownership could therefore lower the cost of management and could contribute to more stability in resource extraction.

HI. Community and Cooperative Management

Community or co-operative management and ownership has been successful for certain resources that are relatively stationary such as shellfish or scallops (Pinkerton,Yamamoto). The advantage of cooperative or community management lies in the reduction of monitoring and enforcement costs and in the vested interest resources users have in the ongoing sustainability of the resources that their livelihood and "way of life" depends on. A problem arises when the resource is migratory or fugitive and resource users lose a sense of ownership and control because the resource is harvested beyond their community environment or their cooperative management area. In the latter case it is important to understand resource users' harvesting behaviour and if necessary to create the proper incentives to achieve a socially optimal outcome.

Common property by definition corresponds to property that is owned by a group of people.

A cooperative or labour managed firm consists of members that are owners and suppliers of labour. As opposed to private enterprises labour is not hired at a market-determined wage rate but is the residual claimant and controls the firm (Ireland & Law, 1982). Cooperative members can either have an equal share in the output or could be rewarded according to their relative supply of effort. A remuneration rule that is strictly based on the relative input of effort or labour would result in the same problem as the limited access to a common property resource. In fact the labour managed firm or cooperative is common property by definition and remuneration according to relative labour input would create an incentive to oversupply effort because members would want to maximise their share of the total output. The only difference between common property resource extraction and relative labour input remuneration in a labour managed firm is that the latter would require to measure effort. An equal sharing rule, on the other hand, does not require the monitoring of labour input as total output is equally distributed among members . With an equal sharing rule each cooperative member wishes to solve the following problem:

$$\max_{e}.\frac{Q(e+\widetilde{E})}{N}-we \qquad (7)$$

resulting in the necessary condition:

$$\frac{1}{N}Q_{E}(1+\frac{\partial\widetilde{E}}{\partial e})=w \quad . \qquad (8)$$

The term $\frac{\partial\widetilde{E}}{\partial e}$ indicates the individual worker's expectation of the total labour supply response to a change in his or her own supply of work hours (Ireland & Law, 1982). An optimal supply of effort is only achieved if $\frac{\partial \tilde{E}}{\partial e}$ =N-1 or if cooperative members have peer pressure to supply the efficient amount of effort because they are perhaps constantly observed by their colleagues who partially own the cooperative. Under the Cournot-Nash assumption , $\frac{\partial \tilde{E}}{\partial e} = 0$, and each member decides on a labour input given the labour input of other members expecting no change in the decisions of others when changing his or her own labour inputs. With zero conjectural variation (Cournot-Nash assumptions) individuals supply too little effort if membership exceeds one. Sen (1966) shows how a fixed membership cooperative can establish an efficient individual labour supply by setting an appropriate internal incentive structure. Sen derives a rule that distributes a proportion of output according to work hours and a proportion independently of labour input equally among members of the cooperative. The sharing rule results in the efficient labour supply of cooperative members under Cournot-Nash assumptions and requires the monitoring of individual's labour input. Sen's sharing rule can be applied to cases where the size of membership is at a level where the average value product of labour exceeds the marginal value product of labour, and consequently membership size is larger than optimal.

A CPR creates an incentive to overharvest if resource users think that their action will have no impact on all other resource users' harvest behaviour. By forcing people to share their output with other users, the incentive to oversupply effort would be reduced and a socially optimal harvest could be achieved. As opposed to Sen's cooperative sharing rule this approach could be achieved without cooperation and formal organizational structures and without the monitoring of relative labour input since resource users' supply of effort can easily be measured by their individual harvest output. A first-best solution depends on the behavioural expectations of harvesters and the optimal division of resource users into output sharing partnerships. An alternative management approach that is based on common property ownership, control and management is therefore explored next.

IV. An Output Sharing Solution to the Tragedy of the Commons

A noncooperative solution to the fundamental problem of the commons can be achieved by maintaining common property rights and without reorganizing harvesters into new organizational institutions. Inefficiencies in the supply of effort as in the LMF prevail if the CPR remains common property. Shirking incentives, however, are desirable to a certain degree if resource users harvest noncooperatively on their own. The optimal arrangement of output sharing can create the right incentives to harvest in a socially optimal manner as the following model shows:

let N=fixed number of resource users
K=number of partnerships
E=total effort supplied by all harvesters
e=individual's effort supply
$\tilde{e}$ = all other team member's effort supply
$\tilde{E}$ = all other teams' supply of effort
p=market price of output normalized to one
w=the opportunity cost of effort
Q(E)=total output

Effort is voluntarily supplied within the team, and therefore is not subject to a joint decision on the team's output, i.e. individual resource users cannot communicate or plan a joint harvesting decision.[2] Each output sharing team consists of N/K resource users that harvest individually but equally share

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[2] One approach to avoid collusion in partnerships is to randomly assign resource users to different partnerships after every harvesting round.

output. The model determines the socially optimal number of teams (K) and team size (N/K). Each resource users' profit maximisation problem is to:

$$\max_{e}. \frac{K}{N}\frac{e+\tilde{e}}{e+\tilde{e}+\tilde{E}}Q(e+\tilde{e}+\tilde{E})-we \qquad (9)$$

resulting in the following necessary condition:

$$\frac{K}{N}\left[\frac{(1+\frac{\partial\tilde{e}}{\partial e})E-(e+\tilde{e})(1+\frac{\partial\tilde{e}}{\partial e}+\frac{\partial\tilde{E}}{\partial e})}{E}\frac{Q(E)}{E}+\frac{e+\tilde{e}}{e+\tilde{e}+\tilde{E}}Q_E(1+\frac{\partial\tilde{e}}{\partial e}+\frac{\partial\tilde{E}}{\partial e})\right]=w \qquad (10)$$

The result indicates two conjectural variations, one that is already familiar from the fundamental problem of the commons model (see equation (4)) and a new conjectural variation that is team-specific. It is necessary to distinguish between the resource users' expectations of team members' response and of all other harvesters' response. From equation (10) the individual's supply of effort can be derived as a function of w,N,K, $\frac{\partial\tilde{e}}{\partial e}, \frac{\partial\tilde{E}}{\partial e}$. The latter two variables are equal to zero under Nash-Cournot conjectures and might represent the outcome of a one-shot game or a repeated game with randomly selected team members.

Equation (10) enables us to describe the effort supply behaviour of individual harvesters as a function of the exogenous variables w and N and the endogenous team number variable K:

$$e=f(w,N,K) \quad . \qquad (11)$$

The socially optimal number and size of teams for a fixed number of fishers can be determined by solving individual team members' optimisation problem and deriving e as a function of k. A social welfare function could sum up all of the fishers' individual incomes after substituting Ne(w,N,K) for E in Q(E) and can be maximised with respect to k in order to find the socially optimal supply of effort:

$$\max_{k} pQ(Ne(w, N, K))-we(w,N,K)N. \qquad (12)$$

The first order condition requires:

$$\frac{\partial Q}{\partial K}\frac{\partial K}{\partial E}N\frac{\partial e}{\partial K} = wN\frac{\partial e}{\partial K} \qquad (13)$$

which is equivalent to: $Q_E = w$.

A first-best solution to the "Tragedy of the Commons" can be found by organising fishers into equal sharing arrangements with the optimal number of team members determined by K*. The number of teams depends on N, w and $\frac{\partial Q}{\partial K}\frac{\partial K}{\partial E}$ (and p that was normalised to 1 in this analysis) .Cournot-Nash behaviour would result in:

$$\frac{K}{N}[\frac{E-e-\tilde{e}}{E}\frac{Q(E)}{E}+\frac{e+\tilde{e}}{E}Q_E] = w \qquad (14)$$

and since all of the harvesters are identical in this model, E=eN and $\tilde{e} = \frac{N-K}{K}e$ we can further simplify to:

$$\frac{K-1}{N}\frac{Q(E)}{E}+\frac{1}{N}Q_E = w \qquad (15)$$

Equation (12) describes the Cournot-Nash behaviour in the extraction of a CPR with K teams and N harvesters. It can lead to the socially optimal extraction if K is chosen so that Q_E=w. The first-best solution in this case therefore consists of choosing K^* according to:

$$K^* = 1 + \frac{(N-1)Q_E(e^*N)}{\frac{Q(e^*N)}{e^*N}} \quad . \qquad (16)$$

The optimal number of teams can be approximated by $N\frac{Q_E(e^*N)}{\frac{Q(e^*N)}{e^*N}}$ for a large number of harvesters which is always smaller than N because Q(E)/E is always larger than Q_E in a common property extraction problem. It would be necessary to allow entry of new resource users if Q(E)/E was smaller than Q_E.

The derived solution to the tragedy of the commons is based on noncooperative behaviour of resource users. In practise, however, harvesters often communicate with each other or can perhaps observe other resource user's behaviour and practices. The application of the proper management approach therefore depends on the nature of the common property and the individuals' effort supply behaviour. Particularly in smaller communities harvesters must expect that their actions will have an impact on other harvesters' decisions to a certain degree. If a CPR lies in the boundaries of a community perhaps no government intervention or independent management institution is required as the examples of the Maine lobster fishery and the Japanese community based coastal fisheries management system have shown. In the Japanese coastal fishery and the Maine lobster fishery territorial user rights for fisheries (TURFs) were established that enable the management of stationary resources that remain within predetermined boundaries. The examples demonstrate that community management can work well when resources can be captured within community boundaries because it limits the mobility of harvesters and therefore the anonymity of effort supply. A resource that stays and is harvested in a community is considered a true common property and its continued existence is vital for community members who reduce their effort levels if they are constantly reassured that others do likewise.

A migratory species or a large aquifer that can be accessed from many different communities or even states (as some large aquifers in the United States for example) is more vulnerable to the tragedy of the commons because harvesters don't expect that their actions have an impact on all the other resource users' behaviour. In the case of several communities or harvesters that use different gears to capture migratory CPRs or CPRs that extend over large territories Nash-Cournot behaviour is more likely. If team members are from the same community, harvest in proximity or communicate regularly with each other it is not conceivable that Cournot-Nash behaviour within the team is a legitimate assumption. The Japanese community based coastal fisheries management system case involves the pooling of some of the catch of migratory species with an equal distribution among cooperatives from different communities. If teams perfectly colluded it would be necessary to have just one team in order to avoid the fundamental problem of the commons. One large team, however, is unlikely to discipline its members to supply a sufficient amount of effort. It is furthermore possible that optimal team sizes could be smaller than the total number of harvesters in a community, and team members might consequently anticipate that their actions could have an effect on not just their team members' effort supply. Community and social capital boundaries therefore should be taken into consideration when determining the optimal division of harvesters into output-sharing partnerships. A more general interpretation of conjectural variations that considers community information and social capital is therefore necessary.

The information set or social capital that is shared among resource users (for example in communities) can be expressed in the form of conjectural variations as $\frac{\partial \tilde{E}}{\partial e} = \overline{C} - 1$. If the number of resource users equals $\overline{C}$, every resource user would expect that his or her effort decisions will have an effect on all other users' decisions and therefore supplies the socially optimal quantity of effort. The latter is the example of a sedentary CPR that stays within the boundary of a community or a group that shares an information set. Unrestricted access to common property really only becomes a problem if resources are migratory or can be accessed by users that share different information sets or social capital. Harvesters then think that their actions have no effect on the decisions of resource users outside of their information set and an overall incentive to overharvest is created. Even if team members come from different sources of social capital, individuals will behave differently than under Nash-Cournot conjectures because they can observe harvesters and are observed from harvesters within their information set boundaries. On the contrary, resource users that team up with individuals that share the same social capital might collude and cause the fundamental result of the commons because they cannot trust the effort supply of other teams. The optimal umber of teams is consequently affected by the boundaries of social capital and of the CPR and equation (10) can be used to examine solutions when Nash-Cournot behaviour within teams or among individual harvesters is not justified.

If team members are randomly assigned from different information sets but share social capital with other harvesters, $\frac{\partial \tilde{E}}{\partial e} = \overline{C} - 1$ and $\frac{\partial \tilde{e}}{\partial e} = 0$ resulting in the optimal number of teams of:

$$K^* = \overline{C} + (N - \overline{C})\frac{Q_E(e^* N)}{\frac{Q(e^* N)}{e^* N}} \quad . \qquad (17)$$

The optimal number of teams therefore is larger than $\overline{C}$ if N> $\overline{C}$. This is consistent with setting

$K^{*}=N$ if $N=\overline{C}$ as in the example of sedentary resources. The optimal number of teams with the consideration of community boundaries or social capital is larger than under Nash-Cournot assumptions because $\frac{Q_E(e^{*}N)}{\frac{Q(e^{*}N)}{e^{*}N}} < 1$. Less shirking incentives are necessary and consequently smaller partnership sizes (less partnerships in total) are required when resource users share information with harvesters with which they do not share output.

Random assignment of harvesters might prove to be impractical, expensive or politically unfeasible particularly if communities have already established resource sharing or allocation mechanisms. An alternative to random assignment is to either have an ongoing partnership with resource users that do not share the same information set or to allow team members from the same community to share output. Both of these approaches result in different optimal assignments of harvesters. Individuals that share output on an ongoing basis but do not share social capital learn about their team members behaviour and therefore adjust their effort supply decisions according to the following conjectural variations:

$$\frac{\partial \tilde{e}}{\partial e} = \frac{N-K}{K}$$
$$\frac{\partial \tilde{E}}{\partial e} = \overline{C} - 1$$

Individuals therefore share an information set with the team they are working with and the community or group they live with or harvest in proximity to. The optimal K in this case is equal to:

$$K^{*} = \frac{N}{N-\overline{C}+1} \qquad (18)$$

An output-sharing solution in this case is only feasible if all team players do not stem from the same community (otherwise the conjectural variations are different). This rules out the solution of having just one team and any team size that is larger than $\frac{N}{\overline{C}}$ which leaves K*=2 as the only possible solution. The optimal team size would be equal to one if there was no social capital and the same team would share output indefinitely. This result only holds under the assumption that any group size can develop enough discipline to voluntary restrict its individual supply of effort. The assumption seems rather unreasonable and the limits to creating team capital or discipline should probably be tested in experimental settings. Even if the ratio of communities (or social capital boundaries) to the total number of harvesters would allow the optimal number of teams to be equal to two it is questionable if two relatively large teams would be able to develop such a large disciplining effect. It is more likely that the voluntary restriction of effort or that the ability to share information effectively is bound by the size of communities and that therefore $\frac{\partial \tilde{e}}{\partial e} + \frac{\partial \tilde{E}}{\partial e} \leq \overline{C} - 1$. Due to limited set of solutions with grouping non-community members in teams on an ongoing basis it would make more sense to use already developed community

structures.

If team members share both social capital and output and there is an upper boundary on the aggregate conjectural variation, $\frac{\partial \tilde{E}}{\partial e} = \overline{C} - 1 - \frac{N-K}{K}$ and $\frac{\partial \tilde{e}}{\partial e} = \frac{N-K}{K}$. This leaves two different scenarios because of the upper boundary of $\frac{\partial \tilde{e}}{\partial e} + \frac{\partial \tilde{E}}{\partial e} \leq \overline{C} - 1$; either $\frac{N-K}{K} < \overline{C} - 1$or $\frac{N-K}{K} = \overline{C} - 1 \; and \; \frac{\partial \tilde{E}}{\partial e} = 0$. In the former case no partnership solution can be determined while the latter case results in the following optimal number of teams:

$$K^{*} = 1 + \left(\frac{N}{\bar{C}} - 1\right)\frac{Q_E(e^{*}N)}{\frac{Q(e^{*}N)}{e^{*}N}} \quad . \qquad (19)$$

The optimal number of teams is smaller than under Cournot-Nash conjectures as long as there are more communities than resource users. The optimal number of teams should also be smaller than the number of communities ($\frac{N}{\bar{C}}$) because $\frac{Q_E(e^{*}N)}{\frac{Q(e^{*}N)}{e^{*}N}} < 1$. Resource users in this case should share with members from other information sets or communities. In order to avoid excessive harvesting within the community it becomes optimal to have less teams than groups that share social capital resulting in a group size that should be larger than $\bar{C}$. The optimal number of teams is a decreasing function of $\bar{C}$ and as $\bar{C}$ approaches N, K^{*} approaches one.

V. **Conclusion**

The optimal incentives in the extraction of common property resources can be established by introducing output sharing arrangements. This management regime has the advantage that resource users can still harvest noncooperatively and can keep long term ownership of the resource. Noncooperative common ownership has the advantage that property rights do not need to be reassigned and resource users do not need to make democratic decisions about joint harvesting decisions. The latter could cause coalition-building and could therefore weaken a common property regime. No annual total allowable catch is imposed by a third source of which resource users often are suspicious of. Policymaker's interest, for example, can easily be based on election cycles and not on the long-term interest of resource users. If the resource lies within the limits of all of the resource users' information set or authority system it might be best not to interrupt regular fishing practices. The use of different technologies or resources that extend beyond harvesters' information sets, however, requires output sharing in partnerships that can take on different forms.

The assignment of resource users to output partnerships can either be random after every harvest interval (a week, a month or a year) or partners can share with the same users indefinitely. This depends on the existing community structures or on social capital. Random assignment is the more recommendable management regime if resource users do not share any social capital or common information sets. With preexisting community structures, on the other hand, both random assignment as well as continuing team membership are possible management regimes. Continuous partnerships require to have larger teams whose total number is smaller than the number of existing communities while random assignment demands to have more partnerships than under Coumot-Nash conjectures. The ideal setup depends on individual resource users' and communities' preferences. If communities, for example, are not comfortable to share in large teams with other communities, random assignment might be a better solution, at least temporarily. The output sharing approach is a way to bring resource users of different communities or interest groups together and eventually people might feel comfortable to work in larger groups and thereby extending social capital.

Further empirical and experimental research could examine the merits of each approach and contrast it to quota management, particularly under resource stock uncertainty that is increasingly prevailing in many common property resources.

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