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Leadership, Coordination and Cooperation in Common-Pool Resource Management*

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Abstract

"This person is at the heart of the system" said a Nepalese farmer about the leader of their irrigation system, "without him there would be no irrigation". There is ample empirical evidence of the importance of leadership for successful management of common-pool resources (CPRs), not least in dealing with the effects of various kinds of disturbances. However, it is hard to find a way to fit leadership into the theories of CPR management, especially if we also want to understand the emergence of leadership. In this paper I develop a model that provides a theoretical explanation for why there are leaders in CPRs, how the leader is selected and who will be the leader.

I treat the interaction between CPR users as consisting of a number of different encounters, with different characteristics. Some encounters are best described as non-cooperative games and some are best described as coordination games. Focussing first on coordination-like encounters, I provide a theoretical motivation for the existence of leadership. I model the role of leadership as being a focal point, or focal person, of coordination games and present conditions for when the chances are higher of achieving coordination on individuals than on actions.

Shifting focus to the whole CPR situation, I then suggest that by viewing CPR management as a mixture and interplay between coordination and cooperation games, the effect of precedence may account for some of the mismatch between theoretical predictions and empirical results on the extent of cooperation in CPR dilemmas. If coordinating on a leader and letting this person decide was efficient in solving coordination problems, then others may be expected to follow a similar strategy in encounters similar to non-cooperative games too. This explains both the existence of leadership in non-cooperative game type of encounters and the high extent of cooperative outcomes.

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1 Introduction

"This person is at the heart of the system" said a Nepalese farmer about the leader of his irrigation system. "Without him there would be no irrigation", said another farmer about the leader of another irrigation system.[1]

There is ample empirical evidence about the importance of leadership to the successful management of common-pool resources (CPRs). The tasks of the leaders range from day-to-day management and decision-making to conflict solving, rule-changing and initiating more extensive changes in the institutional structure of the system. Despite this, it is hard to find room for leadership in existing theories of CPR management and institutional development. In this paper I attempt to remedy this by developing a model that provides a theoretical rationale for leadership in CPR management. The model provides clear results about why it is beneficial to have a leader, how a leader can be identified and who this should be. The model also contributes to explaining the mismatch between theoretical predictions and empirical and experimental evidence of the level of cooperation among resource users.

CPRs have been studied for a long time and there is by now a large literature ranging from theoretical models to empirical studies and experiments analyzing the way CPRs are used and managed.[2] Non-cooperative game theory, in particular the prisoner's dilemma game, has often been used to capture the problems facing CPR users. Apart from predicting lower levels of cooperation than what is observed empirically, an inherent problem with these games is that they have multiple equilibria and that very little is said about how the users can coordinate on a "good" equilibrium, or even end up playing the same game. There is also an extensive use of other types of games, such as various kinds of coordination games, to illustrate the problems of CPR users.[3] In this paper, instead of trying to identify which type of game that fits best, I acknowledge that the interaction between CPR users consists of a number of different encounters with different characteristics.[4] I assume that some encounters are best described as cooperation games and some are best described as coordination games. I then show that the role of leadership can be to be the focal point of coordination games, thereby facilitating coordination. Finally, I link the role of leadership in coordination games to the positive outcome of cooperation games by referring to the literature on precedent in prisoner's dilemma games: The success in solving coordination problems may be transferred to prisoner's dilemma types of problems as a result of an expectation that others will listen to the leader in these situations too.

Before proceeding, I would like to provide the reader with a practical example to use as a background to the discussions in the paper. The farmers quoted above

[1] Expressed by respondents in Ternström's (2005 and 2002) survey of irrigation systems in Nepal.

[2] Recall that "common-pool resources are one's for which exclusion from the resource is costly and one person's use subtracts from what is available to others". National Research Council (2002) p.18.

[3] See e.g. Baland and Platteau (1996).

[4] This is in line with Ostrom's (1990) view on CPRs.

are users of farmer-managed irrigation systems, a well-studied and commonly occurring example of CPRs in developing countries. One standard design is where the irrigation system consists of an irrigation canal with its intake in a river. The water in the main canal is distributed into branch and sub-branch canals before reaching the farmers' fields. The amount of water each farmer obtains depends partly on the amount of water in the river, decided by rainfall and upstream conditions and partly on how much of it that reaches his fields, which depends on the state of canals and intakes and on how water is allocated among the farmers. The canals must be repaired and de-silted more or less frequently, the intake has to be rebuilt or repaired annually or after floods, and the water must be distributed among farmers' fields. To accomplish this the farmers need to cooperate with each other on a number of different tasks and issues. There is often an intricate set of rules regulating for example contribution of labour, allocation and distribution of water, punishment of rule-breaking and changing of rules. Finally, there is leadership, in general exercised by one or a few individuals. These leaders organize and coordinate the other users to carry out repair and maintenance works, they solve conflicts, call the others to meetings, make sure that water is allocated and distributed as agreed, punish rule breakers, change or initiate changes to rules, and generally ensure that the irrigation system functions smoothly.

An irrigation system thus consists of both physical, institutional and social structures and processes. Among the institutional structures are solutions to the problems of allocation and distribution of water. Allocation refers to the way water is allocated among farmers, and may be based on for example land holding size or the need for water. Water distribution refers to the actual movement of the allocated amount of water onto the individual field. Maintaining the system of canals also involves agreeing on how to share the costs and distribute the tasks among the users. Dayton-Johnson (2003) refers to these allocation and distribution issues as different dimensions of institutional forms in farmer-managed irrigation systems.

I would like to suggest that another dimension is whether the interaction between users on a particular issue is best characterized as a non-cooperative game or a coordination game. In non-cooperative games, such as the prisoner's dilemma game, the individual user can gain from not cooperating with the other users. A typical example of this would be the allocation of water among farmers: If one farmer deviates by taking more than his allotted share of water, he may increase his harvest. But if all deviate, they will all be worse off than if they had stuck to the agreement. In a coordination game, the actors need to coordinate on the same equilibrium in order to get the highest payoff, such as when or where to have a meeting, exactly where to dig a canal or the time for repairing headworks or desilting canals. Thus it is in all users' interest to cooperate - the problem is instead that they have to coordinate their actions, which may be difficult enough. Perhaps one problem with our game theoretical analyses of CPR management is that we have taken the quest for simplification too far - thereby making things more complicated than they are. Consider instead the picture of a common-pool resource management system as consisting of many

different sub-tasks or -problems. Some of these are rightly characterized as problems of cooperation among users, and may as such be captured theoretically by the use of non-cooperative game theory and especially the prisoners' dilemma game. Other tasks or problems may be better characterized as coordination problems and these issues should be analyzed as coordination games. Thus, instead of analyzing some CPRs with prisoners' dilemma games and some CPRs with coordination games, we view the game type as an institutional dimension within each CPR system. An example in this direction is when Sethi and Somanathan (2006) focus on the governance problem within CPR management and show that it may be modelled as a coordination game. This is similar to what Calvert (1992) refers to as derived coordination problems, such as the choice of which equilibrium to focus on in repeated cooperation or coordination games.

The division into cooperation problems and coordination problems provides for a nice link to some results of experimental games on cooperation in prisoner's dilemma games. Ahn et. al. (2001) and Knez and Camerer (2000) show that having a history of efficient outcomes in coordination games increases the probability of cooperative play in the prisoner's dilemma game. If CPR management indeed consists of a mixture and a shifting between different types of problems, this may be part of the reason why CPR users behave more cooperatively than predicted by theories built solely on non-cooperative game theory. By shifting between coordination and cooperation problems, efficient coordination would have a positive effect on the users' ability to cooperate.

Knez and Camerer (2000) also find that the effect of a precedent of efficiency in coordination games is stronger if the coordination and prisoner's dilemma games are descriptively similar. Descriptive similarity refers to the number and identity of players, what actions they can take and how these are labelled, the rules of the game, etc. In a CPR setting, where the same group of people are involved in a number of activities, there is certainly an extent of descriptive similarity between the coordination and the cooperation games. Below, I suggest that leadership may provide one more source of descriptive similarity.

Agrawal (2001) lists appropriate leadership as one important group characteristics in his synthesis of critical enabling conditions for sustainability on the commons. Although Agrawal's purpose is to illustrate the abundance of such conditions, it is nevertheless interesting to note that this particular characteristic has received relatively little attention in theoretical analyses of CPRs. Agrawal's synthesis is based on the studies by Baland and Platteau (1996), Ostrom (1990) and Wade (1988) but many other other empirical studies also emphasize the importance of leadership, see for example Khwaja (2001), Meinzen-Dick et. al. (2000), Pérez-Cirera and Lovett (2006), Ternström (2005 and 2002) and Yoder (1994).

The tasks of leaders reported in Ternström (2005) range from day-to-day management and decision-making to conflict solving, rule-changing and initiating more extensive changes in the institutional structure of the system. This is similar to the role of leadership as described in the literature on organizational development and management theory. Mintzberg (1973), for example,

describes the leader's role as focusing on strategy-making, stability, adaptation to changing environment, informational link and that the organization serves the persons who control it.[5] Jackson and Carter (2001) emphasize decision-making. Milgrom and Roberts (1992), in their textbook on economics, organization and management state that "The key role of management in organizations is to ensure coordination".[6] There is also experimental evidence that leaders can improve efficiency in coordination games. In Brandts and Cooper (2006) and Brandts, Cooper and Fatas (2007) leaders are the ones taking the first steps towards more efficient equilibria.[7]

In much of the economics literature leadership is treated as exogenous and the focus tends to be on formal authority. In situations where property rights give right to control to certain individuals, this may be justified. However, in CPR management leadership is obviously not granted on the basis of ownership to the resource and neither is it possible to explain the appointment of leaders with models of democratic elections. Hence it is necessary to find a way of explaining both the existence and function of leadership in groups where there is interdependence but not formal or contractual relationships between individuals. That is, where nobody has the power to force anybody else into taking a certain action. Thus a key aspect of groups of CPR users is that since there is no formal source of power, a leader can only make decisions that are sanctioned by the group.[8]

A theoretical model of such a situation is developed in the sections that follow. To accomplish this, I focus first on those encounters that can be characterized as coordination games and model the users' coordination efforts as a series of coordination games. Schelling (1960) introduced the idea that people use symbolic details to create focal points as a way to coordinate on the same equilibrium.[9] I introduce the concept of focal person as a way to describe the choice and function of leaders in informal groups.[10] In short, what I suggest is that the role of a leader is to *be* the focal point, that is, the thing being coordinated upon, rather than to create or contribute to common knowledge by making decisions and communicating them to the other users as discussed by for example Foss (2001).[11] I do this by simply letting the leader be a person that the others have chosen to listen to, thus defining a leader as someone

[5] Mintzberg (1973) p. 5.

[6] Milgrom and Roberts (1992) p. 114.

[7] See also Kopelman et.al. in National Research Council (2002) for a brief summary of the experimental psychology literature on under what conditions group members opt to appoint a leader to help them solve commons dilemmas.

[8] This makes the model different from e.g. models of elections, where it is implicitly assumed that the winning candidate, once elected, can do anything within his formal authority. Of course, he has an interest in making sure he is re-elected, but he still has the authority to force also those not voting for him to follow his rulings. For more on political economy see e.g. Besley and Coate, (1997).

[9] See also e.g. Sugden (1995).

[10] One advantage with this approach is that it is not backward looking in the same way as is Schelling's theory of focal points. See e.g. M.C.W. Janssen, (1998).

[11] Foss (2001), however, treats leadership as exogenous.

that others follow voluntarily.[12] The way this focal person is identified depends on the structure of preferences and information: If preferences are identical or if there is no information about the others' preferences, physically observable characteristics will be used to identify a focal person. If preferences are not identical the median voter theorem can be used to identify a focal person. The model provides clear results about when it will be beneficial to coordination to have a leader, how a leader can be identified and why this person's leadership will be accepted.

While leaving the actual modelling of the shift between different types of games to a later paper, I then show how the results of the leadership/coordination model fits into the view of CPR management as consisting of shifts between coordination and cooperation types of encounters. By referring to the experimental results on precedent in prisoners' dilemma games I am able to explain why leaders play an important role also in cooperation types of encounters.

The paper proceeds as follows: Sections 2, 3 and 4 focus on coordination types of encounters. Section 2 presents the model which is then used in Sections 3 and 4 to analyze and compare the probabilities of coordinating on actions and individuals, and for making suggestions about how to achieve coordination on an individual. In Section 3 the focus is on a pure coordination game, in Section 4 on a mixed interests coordination game. In Section 5 I put the coordination and leadership pieces back into the picture of a CPR management system as consisting of a number of different encounters of different types. Section 6 concludes the paper.

2 The Model

The following three sections focus solely on finding a way to model leadership in coordination problems encountered by groups of CPR users. Let the group of people using the CPR consist of N individuals. Now and then this group of people encounter situations, or coordination occasions, labelled x, where they can increase their individual well-being by coordinating their actions, a. I find it useful to think about these situations as projects, each of which can be implemented in a number of different ways, but only if enough of the individuals choose to implement it in the same way, i.e. take the same action. If a project is implemented, those who took this action get a positive utility from the project, while the others get zero utility from it. Thus, exclusion is possible and may be voluntary.[13] If too few choose the same action, the project can not be imple-

[12] Definition by Max Weber, see Gerth and Mills (1946) pp.248-250, quoted by Hermalin (2007). There are numerous other definitions of leadership, see.e.g. House and Baetz (1979). Hermalin (1998 and 2007) are perhaps the papers most similar in the definition of leadership and in the quest to find an economic theory of leadership. However, Hermalin analyses the question of how a leader induces followers to follow voluntarily in a setting where there are contractual relationships between individuals (employer and employees) and builds his analysis on asymmetric information.

[13] Note that this makes it different from a public goods problem.

mented, and there is no change in utility for anyone. Examples of such projects are the choice of exactly where to dig an irrigation canal, when and where to have a meeting or exactly when to try to move a boulder blocking the flow of water in an irrigation canal.

A key assumption is that although the individuals are dependent on each other in the use of the CPR, they are otherwise independent enough that nobody can be forced to do anything against their own will.[14] I assume that the environment of the CPR is such that there is no third-party enforcement by for example government agencies, an assumption close to reality in many developing countries. I further assume that preferences are such that each individual is able to perfectly rank different ways of implementing projects, and hence actions, on the basis of his or her own preferences.[15] Finally, for reasons that will become clear later on, I assume that physically observable characteristics, such as a person's age, size of houses and landholdings or the number of cattle a person has are common knowledge, i.e. all individuals have perfect information about the other individuals' physically observable characteristics.

Hence, each individual $i \in \{1, 2, .., N\}$, will at each coordination occasion $x \in \{1, 2, ...X\}$ have to choose an action $a_x \in \{0, 1, 2, ...A_x\}$, with 0 indicating the option not to act and a_i indicating the action chosen by individual i. Let $\widehat{p}$ indicate the minimum proportion of individuals that must choose the same action for it to be possible to implement the project. $p(a_z) = \frac{1}{N} \sum i \,|a_i = a_z$ is the proportion of the CPR users that chooses a certain action a_z. By assuming that $\widehat{p} > \frac{1}{2}$ we ensure that only one action can be implemented, and by assuming that $N \geq 2$ we make the task less trivial.

Let θ refer to the coordination multiplier, which is decided by the share of individuals that coordinate on the same action:

$$\theta(a_z) = \begin{cases} 1 \; if \; p(a_z) \geq \widehat{p}_x; \\ 0 \; if \; p(a_z) < \widehat{p}_x. \end{cases} \tag{1}$$

Note that $\widehat{p}_x = 1$ implies that all CPR users must coordinate on the same action.

The benefit to individual i of choosing action a_i is $\theta(a_i) U_i(a_i)$, where U reflects the net utility of implementing the project by taking action a_i. Assume that U has positive but decreasing marginal utility and $U_i(0) = 0$. Since nobody can be forced to do anything, neither *ex ante* nor *ex post*, nobody will take an action that does not increase his well-being, i.e. that has a non-positive utility to them.

The CPR users have two different ways to try to achieve coordination, each represented by a strategy. If an individual follows the first strategy he privately decides upon an action and announces it to the group (choose-and-tell, subscript $c-t$). Following the second strategy implies selecting one of the other CPR users to listen to and then choosing whether to accept his suggestion or not

[14] This is of course a simplification, not least because it disregards the possibility of retaliating negative behavior on one occasion by punishment in later encounters.

[15] This implies that preferences are uni-dimensional and single-peaked.

(listen-and-choose, subscript $l-c$).[16] The model has three stages: The first involves the act of nature that presents the CPR users with the coordination occasion, the second is where the individuals follow one of the strategies for choosing action and the third is where the project is implemented if enough of the users announced or accepted the same action. Because of the assumption that nobody can be forced into taking an action, all individuals, irrespective of strategy, will only choose actions that increase their utility. Note that for the listen-and-choose strategy to result in coordination, there must be at least $\widehat{p}$ listeners to the same individual, and this individual must choose to make a suggestion (i.e. follow the choose-and-tell strategy).

3 Pure Coordination Game

Calvert (1992) makes the distinction between pure, impure and derived coordination problems. The first two refer to the preferences of the users: In a pure coordination problem preferences are identical but there are multiple, equally valued, equilibria. In impure coordination problems the situation is further complicated as individuals' preferences are not identical. Finally, derived coordination problems are for example the development of norms as a way to choose among equilibria in repeated games. This can be compared to what Ostrom (1990) refers to as collective-choice and collective-action rules, or to developing traditions for identifying focal persons as suggested in Section 3.1 below.

Starting with the simplest case, I assume that projects and preferences are such that the situation can be described as a pure coordination game (indexed PCG), i.e. that all different ways of implementing a project are equally valuable, and equally valued by all individuals. This could for example be the exact time for a meeting, the exact moment to move a boulder blocking a canal or when to clean the headworks after a flood. At least $\widehat{p}$ of the individuals have to choose the same action, and since all ways of implementing the project give the same (positive) utility, each individual wants to be among those who agree.[17]

Let us now look at the chances of implementing a specific project under these assumptions. With N individuals and A_x actions, there are A_x^N different ways to combine all individuals' actions, $A_x^{N\widehat{p}}$ ways to combine the actions of $\widehat{p}$ of them and A_x combinations that can result in implementation.

The probability of achieving sufficient coordination with the choose-and-tell strategy, P_{c-t}^{PCG}, is then

$$P_{c-t}^{PCG} = \frac{A_x}{A_x^{N\widehat{p}}}. \tag{2}$$

[16] This can be compared with Farrell's (1988) idea of having a "speaker" in a pure coordination game.

[17] Note that as long as we assume that the individuals know that the situation can be characterized as a pure coordination game, we have implicitly assumed that they have full information about each others' preferences. On the other hand, this is of little value as it provides no clue about how the others will choose among actions. Hence, the informational structure of the game does not have any effect on the outcome.

A simple numerical example illustrates the difficulties of achieving coordination: With $N = A_x = 2$, there are 4 possible ways to combine the users' actions and a fifty percent chance of achieving full coordination. With 3 individuals and 3 actions, there are 27 combinations and an 11 percent chance of full coordination and with $N = A = 4$ the chance is only 1.6 percent. Recognizing that the number of both actions and actors can be quite substantial, the chances for successful coordination are rapidly dwindling.

The probability of achieving sufficient coordination on an individual, P_{l-c}^{PCG}, is similarly

$$P_{l-c}^{PCG} = \frac{N}{N^{N\widehat{p}}}. \tag{3}$$

Which strategy is more likely to lead to the implementation of the project? This of course depends on the number of actions relative to the number of individuals. To find out when $P_{l-c}^{PCG} > P_{c-t}^{PCG}$ we compare

$$\frac{N}{N^{N\widehat{p}}} > \frac{A_x}{A_x^{N\widehat{p}}}. \tag{4}$$

Rewrite this as

$$N^{1-N\widehat{p}} > A_x^{1-N\widehat{p}} \tag{5}$$

and again as

$$(1 - N\widehat{p}) \ln N > (1 - N\widehat{p}) \ln A_x \tag{6}$$

since N and A_x are positive integers. Since $1 - N\widehat{p}$ is negative (as $N \geq 2$ and $\widehat{p} > 0.5$), this simplifies to

$$\ln N < \ln A_x, \tag{7}$$

and as $\ln y$ is strictly increasing in y, we find that

$$P_{l-c}^{PCG} > P_{c-t}^{PCG} \quad iff \quad N < A_x. \tag{8}$$

Thus, at any coordination occasion characterized as a pure coordination game, the probability of achieving sufficient coordination on an individual is greater than the probability of achieving sufficient coordination on an action if there are fewer individuals than actions. In other words, the chances of achieving coordination are greatest when the individuals follow the strategy with the fewest options.

However, I argued in the introduction that CPR management should be seen as a series of occasions when the users' coordination or cooperation was needed. Here, keeping the focus on coordination types of encounters, I model this by looking at the probability of achieving coordination on X occasions.[18] Following the choose-and-tell strategy then results in

$$P_{c-t,X}^{PCG} = \prod_{x=1}^{X} \left[\frac{A_x}{A_x^{N\widehat{p}}} \right]. \tag{9}$$

[18] Note that this is *not* the same as if they encountered the same situation over and over again; that would be characterised as a repeated game.

Assume for the sake of simplicity that there are as many actions to choose from at all coordination occasions and rewrite this as

$$P_{c-t,X}^{PCG} = \left(\frac{A_x}{A_x^{N\widehat{p}}}\right)^X \tag{10}$$

which is obviously even smaller than P_{c-t}^{PCG}.

Now consider the listen-and-choose strategy. Since we have the same group of people to choose from at each coordination occasion, we again have the same number of alternatives to choose from at each coordination, hence we have

$$P_{l-c,X}^{PCG} = \left(\frac{N}{N^{N\widehat{p}}}\right)^X. \tag{11}$$

Thus we get the same result as with only one coordination occasion.

However, there is one major difference between the two strategies. While in the choose-and-tell strategy the CPR users have a new set of actions to choose from at each coordination occasion, the listen-and-choose strategy always presents them with the same set of alternatives.[19] Hence, the individuals do have the option of making a "once-and-for-all" choice of who to listen to. This can be interpreted as having only one coordination occasion in the listen-and-choose strategy. We are then in a position where the choose-and-tell strategy implies trying to coordinate on one of A_x actions at X occasions and the listen-and-choose strategy implies coordinating on one of N individuals at one occasion. Of course this makes it even more attractive to coordinate on an individual than on actions. Comparing the strategies, we get[20]

$$P_{l-c,1}^{PCG} > P_{c-t,X}^{PCG} \quad iff \quad \ln N < X \ln A. \tag{12}$$

The listen-and-choose strategy becomes relatively more attractive as the number of actions available at each coordination occasion increases and as the number of coordination occasions increases as compared to the number of individuals. That is, the more projects that need the individuals' coordinated efforts, and the more actions there are to choose from, the greater is the benefit of following the listen-and-choose strategy. Rearranging the condition above, we find that whenever

$$X > \frac{\ln N}{\ln A} \tag{13}$$

the best the individuals can do is to choose a "once-and-for-all" individual to listen to.

[19] Assuming that the group of users is stable - more on this below.

[20] To see this formally, rewrite $P_{l-c,1}^{PCG} > P_{c-t,X}^{PCG}$ as $\frac{N}{N^{N\widehat{p}}} > \left[\frac{A_x}{A_x^{N\widehat{p}}}\right]^X$
and againg as $N^{1-N\widehat{p}} > A_x^{X(1-N\widehat{p})}$. Take the natural logarithm to get
$(1-N\widehat{p})\ln N > X(1-N\widehat{p})\ln A_x$.
Since $N \geq 2$ and $\widehat{p} > 0.5$, this simplifies into $X \ln A_x > \ln N$ and we have
$P_{l-c,1}^{PCG} > P_{c-t,X}^{PCG}$ iff $\ln N < X \ln A$.

This provides an economic rationale for the existence of leaders in CPR user groups, where ownership structures do not explain it. However, as was shown in the numerical example above, the chances for actually achieving coordination, even on a "once-and-for-all" leader, are quite small. The next section suggests one way that this may be achieved.

3.1 The choice of leader and the leader's choice

Consider Schelling's theory of focal points, which shows that people have ways of achieving coordination even when there are many similar alternatives.[21] Schelling gave the example of people who are to meet on a certain day in a certain city, but who have not decided when and where to meet. Schelling showed that people manage to coordinate their actions anyway, as there tend to be certain times and places that are "natural" focal points, such as at noon at the central station. In our case, there may be aspects of the different ways of implementing a project that make it easier to coordinate on one of them, such as the place and time of day to meet. However, as there may be many actions to choose from, and a large number of occasions when coordination is needed, it seems unlikely that all projects can be implemented this way.

I propose that just as we may be looking for a focal point among actions, we can look for a "focal person" among the participants of a coordination game. As mentioned in the introduction, this is different from letting the leader help others develop focal points - here, it is not merely a question of the leader making suggestions or decisions, but mainly a question of one individual becoming the leader because others, privately and voluntarily, decide to listen to this particular individual. The individuals do not focus on an action with the help of a leader, but on a person who thus becomes the leader and who they know will propose an action they can accept. Hence it implies focussing on an individual *instead of* on an action.

By introducing the concept of focal person it is possible to increase the likelihood that enough people decide to listen to the same individual, and hence the likelihood that projects can be implemented. We know that under the assumption that projects can be characterized as pure coordination games it really does not matter which way they are implemented. The probability that a project is implemented once a focal person has been identified is thus

$$P_{FP}^{PCG} = 1 \tag{14}$$

where the subindex FP refers to focal person. Hence, it does not matter who is allowed to suggest which action to take and there is no reason for focal characteristics to be related to the implementation of the common project - it could be any characteristic that makes one of the individuals stand out or be a natural focal person in the group.

[21] Schelling (1960).

Recall that I assumed in section two that physically observable characteristics are known to all. Together with the above assertion that any characteristic is an equally good candidate for identifying a focal person, this provides us with ways to distinguish between individuals and hence a possible solution to the coordination problem. If for example there is one individual who is significantly older than the rest, this is a potential focal person. In such case, age would be the "focal characteristic". Similarly, if one of the CPR users is notably more wealthy than the rest, this may make him a focal person and hence increases the likelihood that the users manage to coordinate their actions in an efficient way. This provides a new argument for those who argue that inequality among CPR users has a positive effect on their ability to cooperate. Although there may be more than one potential focal characteristic, some of them are likely to coincide (such as the size of landholding, number of livestock and wealth) and some may be more prominent than others.

The effect in terms of the equations above is to replace N with N^{FP} (for the number of potential focal persons). As long as $N^{FP} < N$ this will make it easier to fulfill the conditions for when the probability of coordination is higher with the listen-and-choose strategy than with the choose-and-tell strategy. Furthermore, the smaller is N^{FP}, the higher is the probability of coordinating on a person. By developing traditions for how to select focal persons, individuals who regularly encounter each other in coordination situations may substantially simplify their coordination problems. This can be seen as an example of a solution to what Calvert (1992) referred to as derived coordination problems.[22]

4 Coordination Game with Mixed Interests

In this section I relax the assumption that individuals have identical preferences and that equilibria are symmetric and look at what Calvert (1992) refers to as impure coordination games. Here the utility an individual gets from a certain project depends on the exact way that the project is implemented and individuals have different ranking of the different ways to implement a project. What we then have can be described as a coordination game with mixed interests. Thus the CPR users have preferences over the different ways that a project can be implemented and these preferences are not identical. It is no longer simply a matter of trying to coordinate on any action but each user would like to implement the project by coordinating on his most preferred action. There is thus a trade-off between achieving sufficient coordination to be able to implement the project at all and implementing the project in a specific way.

In this setting the amount of information the users have about each others' preferences matters to the way they make decisions about what action or person

[22] Calvert (1992) discusses the role of leadership in the development of norms as a way to solve derived coordination problems but although he concludes that "establishing and maintaining leadership itself presents a problem of coordination", he merely refers to it as a process of trial-end-error and a gradual recognition of one person's authority.

to coordinate on. Having full information about the others' preferences would imply knowing exactly how all other participants value all possible ways of implementing all different projects. This seems unlikely in our CPR setting, and I will limit the analysis to the two cases where the users have no information and imperfect information about each others' preferences.

4.1 No information about others' preferences

At each coordination occasion x, individuals know their own preferences, the total number of individuals, the minimum coordination required and physically observable characteristics. It also seems reasonable to assume that they know what kind of game they are in, which implies knowing that they all have preferences over the different ways of implementing projects and that preferences differ. The result is that as in the pure coordination game above, they do not have any information upon which they can base their choice of action in order to promote coordination. Above, the reason was that as they were indifferent between actions, it was impossible to anticipate the choices of the others; here, although they know the others are not indifferent, they do not have any other information about the nature of their preferences. In both cases, based upon the information an individual has, every action is as likely to result in coordination.

First, if all actions give positive utility to all users, we get the same result as above (with index MI, no indicating mixed interest game with no information):

$$P_{l-c}^{MI,no} > P_{c-t}^{MI,no} \quad iff \quad N < A_x. \tag{15}$$

The probability of achieving coordination on an individual is greater than the probability of achieving coordination on an action if there are fewer individuals than there are actions. However, as above the overall probability of achieving coordination is rather low and the option to use physically observable characteristics to identify a focal person can increase the chances of achieving coordination.

Second, if some action(s) results in zero utility for at least $(1 - \widehat{p})$ of the users, the number of different ways that the project can be implemented will decrease. Let $\widetilde{A}_x$ refer to this decreased set of actions that are possible to implement. The probability of achieving coordination by following the choose-and-tell strategy then becomes

$$P_{c-t}^{MI,no} = \frac{\widetilde{A}_x}{A_x^{N\widehat{p}}}. \tag{16}$$

Since $\widetilde{A}_x < A_x$, it follows that this decreases the chance of achieving coordination in the choose-and-tell strategy, and hence increases the relative benefit of following the listen-and-choose strategy.[23]

[23] Note that if there are actions that can not be implemented there is a risk that a focal person suggests such an action. Given that the users have coordinated on an focal person the probability that the project is implemented is now $P_{FP}^{MI,no} = \frac{\tilde{A}_x}{A_x}$. Thus for it to be more likely

4.2 Imperfect information about others' preferences

Will the probability that the CPR users manage to coordinate their efforts increase if they have more information about the each others' preferences? Here we look at imperfect information in the sense that the users know their fellow users' most-preferred way of implementing a project. The access to this information makes it possible for the users to behave strategically. This makes it possible for me to take a different route to calculate the probability of successful coordination.

Consider the median voter theorem.[24] This theorem states that if everyone votes and votes sincerely, and voters have single-peaked preferences, then the ideal point of the median voter defeats any other position in a pairwise vote.[25] I would like to propose that the problem in our coordination game can be interpreted in terms of a voting situation: The CPR users can be regarded as voters, who have different ideal points (preferred actions, a_i^*) and who vote for whom to listen to (in the listen-and-choose strategy) or for which action to take (in the choose-and-tell strategy). If we assume that the CPR users have unidimensional and single-peaked preferences, then as they know each others' most-preferred ways of implementing a project, they can use the median voter theorem to deduce which action and which individual that is preferred by most.

The strong form of the median voter theorem states that if there is a median voter, his preferred policy will beat any other alternative in a pairwise vote.[26] The interpretation in terms of our coordination problem is that if there is a median individual (m), his preferred action (a_m^*) will beat any other action in a pairwise comparison. Thus, in the listen-and-choose strategy, the best that any individual with $U_i(a_m^*) > 0$ can do is to listen to the median individual, as there is no other individual that will get more "votes" (listeners). In the choose-and-tell strategy, the action preferred by the median individual is the action that will be preferred by most individuals. Since the median voter theorem tells us that there can be no other action that is preferred by more individuals than the one preferred by the median individual, and since $\widehat{p} > 0.5$ implies that no other action than the one preferred by the largest share of the individuals can be implemented, there can be only one such person or action.

Thus, (with index MI, imp indicating mixed interest game with imperfect information)

$$p_x(a_m^*) = \frac{1}{N}\Sigma_i\left[U_i(a_m^*) > 0\right] \tag{17}$$

and as long as

$$p_x(a_m^*) \geq \widehat{p} \tag{18}$$

to achieve coordination by following the listen-and-choose strategy than the choose-and-tell strategy we must have $\frac{\tilde{A}_x}{A_x} > \frac{\tilde{A}_x}{A_x^{N\widehat{p}}}$, which is always true since $N \geq 2$ and $\widehat{p} > 0.5$. Hence, even if there is a risk that a focal person suggests an action which can not be implemented, this is still a more reliable way to implement a project.

[24] Hotelling (1929), Black (1948) and Downs (1957).

[25] Black (1963) ch. 4.

[26] Congleton (2002).

we have

$$P_{c-t,x}^{MI,imp} = P_{l-c,x}^{MI,imp} = 1 \tag{19}$$

As long as enough of the users get a positive utility from the median individual's most preferred action, the probability of achieving sufficient coordination at occasion x equals one with both strategies.[27]

An important assumption behind this result is that preferences are homogeneously distributed. If preferences are heterogeneously distributed among individuals, the outcome can become quite different.[28] If for example individuals in one subgroup prefer actions toward one end of the action-dimension, individual in another subgroup prefer actions toward the other end of the action-dimension, and only a few individuals prefer actions in-between, the median voter's action may be acceptable to too few to be possible to implement. On the other hand, if there is one subgroup that is large enough it may become what I refer to as a "ruling subgroup":

Define a subgroup (indexed SG) as a conglomeration of individuals whose preferences are similar in the sense that in a pairwise comparison of actions, they will always prefer actions that are most-preferred by individuals within the subgroup to actions that are most-preferred by outsiders, that is

$$U_{i \in SG}\left(a_{j \in SG}^{*}\right) > U_{i \in SG}\left(a_{j \notin SG}^{*}\right). \tag{20}$$

If such a subgroup contains at least $\widehat{p}$ of the individuals, the preferences of this group will be decisive for the way the project is implemented.[29] We can use the median voter theorem to state that the action preferred by the subgroup's median individual, $a_{m,SG}^{*}$, is the action that will be chosen by all members of the subgroup. Furthermore, rational individuals not belonging to this subgroup, but who derive positive utility from $a_{m,SG}^{*}$, will also choose this action since it is the only way for them to get any benefit from the project.[30]

If there is no single subgroup larger than $N\widehat{p}$, can there still be sufficient coordination? If some of the subgroups are "close enough" that some action(s) can be accepted by at least $\widehat{p}$ of the users, these users could merge into a larger subgroup. In this case we may have a situation where the so constructed ruling subgroup's median voter's preferred action is highly ranked by only a few individuals.

[27] The use of the median voter theorem may also provide us with a possible explanation for why people show such strong tendencies for fairness in experimental games, such as the dictator game. Instead of being an expression of altruism, it may be because of a knowledge that fairness is the best way to get as many people as possible to agree.

[28] See for example Gerber and Lewis (2004) for a discussion of when the median voter theorem does not hold and an empirical analysis of the effect of voter heterogeneity.

[29] This is similar to discussions of minimum winning coalitions, see for example Riker (1962) who provides arguments for why political coalitions will be just large enough to ensure winning.

[30] This is similar to Duverger's law, which explains why there tend to be only two parties in "winner-takes-it-all" elections (Downs, 1957). The reasoning there is that if there can only be one winner, voting for the winner or the main challenger is the only way to make your vote count. Here, the reasoning is that "voting" for the winner is the only way to get a piece of the cake.

An important implication of this result is that if the relative sizes of subgroups change over time, for example because new users enter the group or because of a change in attitudes, this can affect the ability to achieve coordination and the way that projects are implemented. As the relative size of the largest subgroup decreases, it approaches $\widehat{p}$. If it passes $\widehat{p}$ this group can no longer be a ruling subgroup, and there will be a shift in either leadership or action.

This is exactly what has happened in some of the irrigation systems in Nepal that were surveyed in Ternström (2002 and 2005). Periods of high inmigration of new users were followed by periods of challenges to existing rules and leadership. Eventually, as the proportion of new users increased, several of the irrigation systems experienced a shift of leadership or change of rules that were more in line with the new users' preferences. Statistical examination of the data collected in these irrigation systems showed that the relative size of the largest ethnic group ("majority strength") was strongly and negatively correlated with the extent of rule-breaking and disputes.[31]

5 Linking Leadership and Coordination to Cooperation

In the previous sections I showed that leadership can make it easier for the users of a CPR to coordinate their actions. I also showed that the choice of leader can be endogenous and provided a way to identify leaders in the absence of property rights or election procedures. What, then, is the link to those situations in CPR management that are best characterized as non-cooperative games?

In the introduction I referred to Ahn et. al. (2001) and Knez and Camerer (2000) who provide experimental evidence that a precedent of efficient outcomes in coordination games increases the probability of cooperative play in prisoner's dilemma games. If CPR management consists of both coordination and cooperation problems, the shifting between coordination and cooperation problems provides a source of such precedent. Successful solutions to coordination problems would have a positive effect on the users' ability to behave cooperatively in other situations and may thus help explaining why we observe more cooperation among CPR users in real-life than what is suggested by theoretical analyses of non-cooperative games.

Knez and Camerer (2000) also found that the effect of a precedent of efficiency in coordination games is stronger if the coordination and prisoner's dilemma games are descriptively similar, meaning similarity in the number and identity of players, available actions, rules of the game, etc. In a CPR setting, where the same group of people are involved in a number of activities, there is obviously similarity in the number and identity of players. In the coordination games examined above, the role of the leader was to be a person who the other

[31] Ternström (2002).

users listen to and who suggests which action to take, and I showed above that this is often the best strategy to follow to solve coordination problems. It still remains to explain why CPR users in real life seem to follow their leader in other types of situations as well.

Knez and Camerer (2000) p.202, describing the dilemma of prisoner's dilemma players, write that the key challenge for players is to coordinate their beliefs on whether their partner is likely to choose the cooperative path, in which case they will want to cooperate also, or whether their partner is likely to choose the defection path, in which case they will defect too. They also point out that precedent does not imply that people simply repeat what they did in the past. Instead, precedent is about expecting others to do as they did in the past. If there is thus a precedent that the CPR users listen to a leader when trying to coordinate their actions, they may expect each other to follow this strategy in solving problems of cooperation as well. If they thus expect the others to follow the path that the leader suggests, they too will want to do as they leader suggests. This way the benefit of having a leader in coordination situations may help the CPR users to overcome the dilemma of how to choose whether to cooperate or not in prisoner's dilemma situations.

6 Discussion and Concluding Remarks

The main accomplishment of this paper is to remedy the lack of theoretical explanations for the importance of leadership in CPR management. I treat CPR management as a mix of coordination and cooperation problems but focus mainly on coordination problems in the modelling part of the paper. By treating some of the tasks or problems facing CPR users as coordination problems I open up for a way to explain the role and raison d'être of leadership in CPR management. Such an analysis of leadership must take into consideration that in a CPR setting, the choice of leader can not be explained by property rights or democratic elections. In the model presented above leadership is endogenous to the situation and a leader is defined as someone that the others follow voluntarily. I let the users choose between two strategies in the coordination game: Listen-and-choose, which implies coordinating on a person to listen to, and choose-and-tell, which implies choosing an action and hoping that enough of the others have chosen the same action. I show that whenever there are fewer individuals to choose from than actions, it is more likely to achieve coordination on a single individual than on a single action.

I then suggest ways to further increase the probability of coordinating on an individual. In pure coordination games, where all actions are equally valued and equally attractive to all users, it does not matter who is the leader. Hence, any way to coordinate on an individual is fine and I propose that just as we may be looking for a focal point among actions, we can look for a "focal person" among the participants of a coordination game. Any physically observable variable that is known to all users may then be used to identify such a focal person,

for example wealth, land-holding size or lineage. Note that this provides a new argument for those who argue that inequality among CPR users has a positive effect on their ability to cooperate. If one of the users is notably more wealthy than the rest, this makes him a potential focal person and may increase the likelihood that the users manage to coordinate their actions in an efficient way.

In mixed interest coordination games, i.e. where the users have preferences over different equilibria and differ in their preferences, the users would on the one hand like to take the action that they prefer most but on the other hand they have to coordinate with the others to get anything at all. If the users know only their own preferences, there is no way that they can take into consideration how the others may act, and the result is the same as in the pure coordination game. If they know each others' most preferred actions, however, I show that the median voter theorem can be used to predict which action or which person they should choose in order to solve their coordination problem.

Having thus examined leadership in CPR coordination situations, I change focus and look again at the view of CPR management as a shifting between different types of encounters. I tie the result of the leadership model to the mismatch of theory and evidence regarding the extent of cooperative behavior among CPR users by referring to the effect of precedent. There is experimental evidence that a precedence of efficient play in coordination games makes the actors play more cooperatively in a prisoner's dilemma game. If in reality the users of a CPR shift between coordination and cooperation types of interactions, such precedent would matter. Furthermore, the effect of precedent is stronger between situations that are similar in terms of users, actions, strategies, etc. In a stable CPR management system, the users are the same throughout, thus providing for one source of similarity. I suggest that listening to a leader may be a strategy which, because it has proven efficient when solving coordination problems, the CPR users may expect each other to follow also when solving coordination problems.

To find out whether the strategy of following a leader's suggestion is followed in real-life, we need to look closely at how cooperation dilemmas are actually being solved in CPR management systems. One study that attempts to do this is Ternström (2005), where the author traces processes and reactions that are triggered by external disturbances to CPR management systems. The results show that leaders play a crucial role in most of the interactions between these CPR users.

A practical implication of the results of this paper is that the more coordination encounters a group of CPR users have, and the more they shift between coordination and cooperation types of encounters, the better should they be at solving cooperation problems. Except for being empirically testable, this suggests a way of actively improving CPR management. A natural theoretical extension of the paper is to develop a game theoretic model that captures the view of CPR management as consisting of both coordination and cooperation games and shifts between these.

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