

THE MERITS AND DE-MERITS OF GAME THEORETIC APPROACHES TO THE GOVERNANCE OF COMMON-POOL RESOURCES,

with emphasis on cooperative water management.

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WORKSHOP ON POLITICAL THEORY
AND POLICY ANALYSIS
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1. What is Game Theory?

What is game theory? It is quite simply the formal study of rational decision in situations [of interdependence]. Two or more individuals have choices to make, [have] preferences regarding the outcomes, and some knowledge of the choices available to each other and of each other's preferences. The outcome depends on the choices that both of them make, or all of them if there are more than two. There is no independently "best" choice that one can make; it depends on what the others do. Three major assumptions that game theory employs (and there are others, which I don't discuss here) are:

(a) Games have rules or protocols. These tell us how the game can be played and what actions or strategies are permitted at any time.

(b) Individuals select strategies from a strategy space in an instrumentally rational manner. In other words, they have preferences regarding outcomes and select actions which best satisfy those preferences. Rationality is cast in a means-end framework with the task of selecting the most appropriate means of achieving certain ends." Although ordinal utilities suffice in simple decision problems, in situations of decisionmaking under uncertainty it is necessary to invoke cardinal utilities, which communicate information about the ranking *and* strength of preferences. It is, therefore, commonplace to accept the expected utility hypothesis which, with the use of certain axioms, ensures consistent choices over probabilistic outcomes.

(c) Players in a game form (rational) expectations about each other's strategies on the basis of a common knowledge of rationality (CKR), or to put it more simply, they make knowledgeable conjectures about each other's anticipated strategy.

2. Game Theory and Collective Action

Game theory is pertinent to our present discussion precisely because it can, I believe, offer important insights on the subject of cooperation - one of the main concerns of our workshop here.

The two most common game forms utilized in studies on collective action are the Coordination game and the Prisoner's Dilemma game. I will also mention a third game - the Inequality Preservation game - which, strictly speaking, is a subclass of Coordination games.

Illustrations of the Coordination and Prisoner's Dilemma Games

Coordination game

You are on a station platform, ready to board the train and meet an old friend who has reserved a seat in a different car from yours. You agree to meet in the diner. After you board the train a steward comes through making reservations, and you discover that there is a first-class diner and a second-class buffet car. Being a class-conscious individual, you would prefer to eat in first class; but you suspect that your friend, who is of more egalitarian persuasion, would prefer the second-class buffet car. You care for him very much (despite his peculiar politics) and want to make a reservation that coincides with his. Should you elect the diner or the buffet car? The problem is not as clearcut as it seems - i.e. choose the buffet car - because the friend employs a similar process of reasoning. Another example of a coordination problem is crossing a four-way intersection without an accident.

In the jargon, a "coordination" problem exists if the game or decision situation is structured in such a way that at any equilibrium point (in this case, choices that coincide) not only does no player have an incentive to change his behaviour, given the behaviour of other players, but no player wishes that any other player would change either. The distinctive feature of coordination games is that they have multiple equilibria.

The strategic problem for each player in a Coordination game is that he wants to "coordinate" his choice of strategy with his opponents, because for any given choice by his opponent, it is always beneficial to coordinate, yet he is not indifferent as to the exact strategy n-tuple they coordinate on. If a coordination game were a recurrent feature of a given economy or society, rather than trying to solve the game each time it reappears, it would be reasonable to expect agents in an economy to establish some equilibrium mode of behaviour or convention and adhere to it each time the problem arises. Such a convention of behaviour, if adhered to, is a social institution and would allow agents to avoid the occurrence of inefficient nonequilibrium payoffs.

Table 1

		AGENT B	
		Strategy 1	Strategy 2
AGENT A	Strategy 1	0,0	6,4
	Strategy 2	0,0	3,7

* The two Nash equilibria are underlined

(2) Prisoner's Dilemma game

Imagine now that you are on a train without a reserved seat. You find a seat but a few passengers are left standing. When the steward announces lunch, the standing passengers watch eagerly to see who will vacate a seat in favour of lunch. If you go to the diner you will have no claim to your seat when you return. If you do not vacate your seat you cannot eat; if you do not eat nobody gets your seat, not even for the time you would like to be in the diner. What arrangement can you work out? Typically, play of this Prisoner's Dilemma game yields a sub-optimal outcome. I don't leave my seat. One of the standing passengers doesn't get to sit. Even though we could have worked out an arrangement where he could have sat for some time while I visited the diner to eat.

Formally, Prisoner's Dilemma games are games in which for any non-cooperative equilibrium, there exists at least one non-equilibrium outcome that is Pareto-superior, or more beneficial to all players. Consider Table 2. Two agents are asked to contribute monetarily to the provision of a public good, say the weeding and cleaning of drainage channels that support a surface irrigation system; or if you prefer, the desilting of an irrigation tank. The level of provision will depend upon the marginal rate of substitution between this good and an all-purpose private good (for instance, leisure) that agents report to some local or extra-local coordinating authority. The public good is assumed to last only one period, after which it vanishes and the game will have to be played again. In our example, drainage channels must be weeded and cleaned annually; and irrigation tanks must be desilted periodically (the period doesn't have to be a year - it can be any arbitrarily chosen unit of time). The strategies of the two agents in any period are either to lie or to tell the truth to the coordinating authority when it asks their marginal rate of substitution. Based on these reports, the authority will determine the amount of public good to provide.

This problem is a Prisoner's Dilemma game, and, as is customarily thought, if no binding contracts can be enforced between agents, a nonoptimal equilibrium will result in which the public good would be under-provided. However, if the game were recurrent and the

players realized this, both of them might comprehend that repeated use of the lying strategy is self-destructive. Consequently, as the situation is iterated, we might expect a norm of truthful revelation of preferences to be developed upon which the convention of telling the truth would be built. Thus, we could expect social institutions to evolve to solve recurrent Prisoner's Dilemma games.

In Matar Taluka of Kheda District, Gujarat, an annual cycle of irrigated paddy and irrigated wheat cultivation, coupled with excessive application of water to poorly-drained fields, has compounded waterlogging, salinization, and pest outbreak problems. The past 5 to 7 years display a rising trend in the incidence of crop diseases. Cultivators recognize the harm inflicted by an annual regime of paddy and irrigated wheat. Yet, in what is a classic illustration of a collective action problem, they are unable to wean themselves away from the practice.

A direct solution for the pest problem would be to switch away from a hydric cropping pattern to dry cropping for a few years so that the host-specific lifecycle of pests is disrupted. But no individual cultivator has an incentive to stop paddy cultivation unless all cultivators in the vicinity follow suit. Otherwise, the individual cultivator's initiative would be rendered meaningless. But since it is unlikely that cultivators will en-masse alter their cropping practice, the pest problem is bound to escalate further.

Table 2: Public Goods game

		Strategy 1: Be true	Strategy 2: Lie
AGENT A	Strategy 1: Be true	8,10	1,12
	Strategy 2: Lie	12,1	<u>3,3</u>

* The single Nash equilibrium is underlined

(3) Inequality Preserving game

This is often described as a third type of collective action game, although, strictly speaking, it is a subclass of the Coordination game. The game describes the perpetuation of a status quo position of inequality among various economic agents - for instance, a property right or inheritance law. The important feature of these situations is that one equilibrium payoff vector in the situation is given special importance by being designated as the "historical" status quo, and all analysis takes this as the starting point.

Table 3: Status Quo Game

		AGENT B	
		Strategy 1: Status quo	Strategy 2: Change
AGENT A	Strategy 1: Status quo	<u>2,1</u>	0,0
	Strategy 2: Change	0,0	<u>1,2</u>

* The two Nash equilibria are underlined

Although the column player, B, might wish to alter the status quo, if the convention (2,1) is well-defined, such an attempt would fail because the institutional rule supporting (2,1) not only designates it as the accepted mode of behaviour, but also specifies punishment for B if he tries to deviate. This punishment involves A continuing to behave as before (choosing strategy 1) *no matter what*.

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3. Game Theory and Common-Pool Resources

Elinor Ostrom in her book, *Governing the Commons: The Evolution of Institutions for Collective Action*, offers perhaps the clearest - and certainly, the most programmatic - exposition of a game-theoretic approach to the management of common-pool resources. Combining results from static and repeated game models with inductive insights from several case studies, she is able to generate a normative framework for CPR management. She presents these as a set of provisional design principles that permit resource users to overcome the problems of credible commitment and mutual monitoring - two of three major impediments to collective action for the collective good. The third, remaining problem is that of supplying the actual institutions "that create situations in which individuals find it advantageous, credible, and safe to pursue contingent commitments to rule compliance and mutual monitoring." (p.187)

I quickly outline, first, her design principles and, second, her framework (rather than theory) of institutional provision.

A. Design principles

1. Clearly defined boundaries that demarcate the CPR, as well as its legitimate users.
2. Congruence between appropriation (flow) and provision (stock) rules, and local conditions.
3. Collective-choice arrangements that enfranchise appropriators affected by operational rules to participate in the modification of those rules, if necessary.
 - 4a. Presence of monitors who audit CPRs, as well as user behaviour (hence dilute moral hazard, and generate information that permit users to adopt contingent cooperative strategies).
 - 4b. Monitors are accountable to users, or are themselves users (hence subject to disciplining via trigger strategies).
5. Existence of a system of graduated sanctions that are assessed depending on the seriousness and context of the offense (rather than arbitrarily), with assessors either being other users or else a legitimate authority; in the absence of punitive sanctions (and, hence, credible threats), free-riding would prevail. Note that the presence of social norms, or the loss of reputation incurred from violating those norms, may not always be adequate to prevent infractions.
6. Access to low-cost conflict-resolution mechanisms (high transactions costs of settling disputes would otherwise make institutional rules brittle). Since users can always interpret rules opportunistically (arguing they have followed a rule, but in effect subverting its intent), fixity of rules should not be assumed.
7. Recognition by extra-local authority of users' rights to organize local management institutions (i.e., a state policy of minimal interference).

Ostrom then goes on to specify a model of institutional provision. She asserts that status quo rules for CPR use will either change or continue depending upon whether the expected benefits of change exceed or fall short of the expected costs of enacting a change, given prevailing internal (i.e. socialized) norms and discount rates of social agents. She lists a large number of situational (or observable) variables that affect benefits and costs.

Hence, benefits are affected by:

- (1) Number of appropriators
- (2) Size of CPR
- (3) Temporal and spatial variability of resource units
- (4) Current condition of CPR
- (5) Market conditions for resource units
- (6) Amount and type of conflict
- (7) Availability of data about (1) through (6)
- (8) Status quo rules in use
- (9) Proposed new rules

She hypothesizes that the larger the resource system and/or number of appropriators, and the more unpredictable the flow of resource units and the market prices for these units, the most difficult and costly it is for anyone to obtain accurate information about the condition of the resource itself and the likely flow of resource units under any set of rules; thus, making cooperation for institutional change unlikely.

With regard to costs, the situational variables include the standard components of transaction cost (i.e. the cost of negotiating a transaction or arrangement), as well as the expected costs of monitoring and enforcement. These are influenced by:

- (1) Size and structure of the CPR
- (2) Exclusion technology
- (3) Appropriation technology
- (4) Marketing arrangement
- (5) Legitimacy of current rules
- (6) Proposed new rules

Although the lists of variables Ostrom provides are suggestive, they are frustratingly long and tend to obscure what I believe are the key elements to the prospects of cooperation. These can be stated as propositions:

- (A) The lower the level of **strategic interdependence** between social agents, the lower the likelihood of

cooperation. In other words, agents have little reason to cooperate unless they can be convinced that outcomes are jointly produced. Market exchange between a buyer and a seller is a perfect example.

(B) The greater the number of **negotiating items** between social agents, the more likely they will be mutually dependent, and therefore, the more likely that they will cooperate.

(C) The more **uniform** and **recurrently-shared** the social and economic conditions of agents, the more likely they will have mutually consistent expectations and the more likely that they will cooperate.

(D) The more certain the **contingent fulfillment of a threat or commitment**, the more likely that agents will cooperate.

(E) The **less zero-sum** the structure of CPR use, the greater the likelihood of cooperation.

(F) The lower the **information and enforcement costs** of CPR use, the greater the likelihood of cooperation.

(G) The **lower the discount rate** of CPR users (i.e., the less the availability of alternative income substitutes) and the **less the divergence** between their individual rates of discount, the more the likelihood of cooperation.

Provided (C) and (G) hold, I then want to propose that:

(H) The greater the **likelihood of scarcity** in CPR supply, the more the likelihood of cooperation among users.

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4. Shortcomings of Game Theory

Several gaps remain. *First*, game theory is unable to supply a theory of preference formation. Specifically, what is instrumentally rational is not well defined unless one appeals to the prevailing norms of behaviour. This may seem strange in the context of a Prisoner's Dilemma game where the demands of instrumental rationality seem plain for all to see: defect!

But, in reply, one could complain that the norms have already been at work in the definition of the matrix and its payoffs because it is unlikely for any social setting to throw up unvarnished payoffs. A social setting requires interpretation before the payoffs can be assigned and norms are implicated in those interpretations. This should be evident: although we think of 'commodity exchange' as the natural state of affairs, it is in fact a 'naturalized' state of affairs; this becomes starkly clear when we read with shock, for instance, about the underground trade in children or influence peddling in politics. Hence, a social context already determines what we can have preferences over, what payoffs we assign to those admissible preferences, what actions we can contemplate to achieve ends. To speak about preference formation requires us to furnish theories of power and meaning.

Second, game theory neither fully explains the emergence of conventions in social situations with multiple equilibria ("coordination games"), nor does it adequately account for the potentially mediatory role of an external player, nor the persistence of conventions across generations. The "emergence" issue returns us to the domain of preference or expectation formation. Kreps (1990) observes that:

[I]n some games with multiple equilibria, players still 'know' what to do. This knowledge comes from both directly relevant past experience and a sense of how individuals act generally. And *formal mathematical game theory has said little or nothing about where these expectations come from, how and why they persist, or when and why we might expect them to arise.* (his italics)

Meanwhile, the "persistence" issue may require us to furnish theories of socialization and practical action - as I discussed in the introduction. However, there is promise that evolutionary game theory might provide leverage here. Evolutionary games discard the assumption of common knowledge (CKR) or a priori knowledge of payoffs. Instead, they assume that players can learn their own payoffs through actual experience over time (via a Bayesian learning process). Of course, socialization would still circumscribe the menu of initial strategies. But some scholars may view socialization as too passive and deterministic a descriptor of human behaviour. They may instead prefer a post-Saussure and post-Parsons "structuration" approach (cf. Bourdieu or Giddens). Evolutionary game theory should carry appeal for these scholars because it admits the possibility for new and creative strategies - which have the unfortunate label, "mutant strategies", in the literature - to either replace old, established ones (the emergence of heterodoxy) or be suppressed (the continuation of orthodoxy).

Third, game theory has little to say either on the origins of rules that inform a game (Ostrom's explanation, for instance, is weak), the fact that rules may apply unequally across players (for instance, powerful players might not be censured or sanctioned for deviation from rules), or on how prevailing rules may change when games are played in a dynamic setting. This objection has obvious links to the previous two objections. In particular, there seems to be a problem with methodological individualism. The critiques indicate a need to move to an ontology of the social; that is, towards an Aristotelian conception of the world, where society always precedes - indeed, 'makes' - the individual. Or as Heidegger might have said, society supplies individuals with the tools ('equipment') to construct their life-worlds.

Fourth, game theory is hamstrung by the assumption of instrumental rationality. Realism may demand that it attend to other concepts of rationality that appear to guide human actions: such as bounded rationality (which is, strictly speaking, only a modification of instrumental rationality); procedural rationality (Max Weber's notion of "value rational" actions, or Kant's idea of the "categorical imperative"); communicative rationality (cf. Jurgen Habermas); and skepticism over the causal sequence of rationality itself (cf. Leon Festinger's work on "cognitive dissonance", which indicates that preferences are created through acts of choosing - or, from the standpoint of logic, actions precede the reasons for those actions!).

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