

Chapter 21.

The N-Person Prisoner's Dilemma

- Game Representations of the Dilemma
- Tragedy of the Commons
- Management of Common Pool Resources

Characteristic Function

- The characteristic function enumerates possible coalitions
- For each coalition, it lists the value created or destroyed

$$\begin{array}{lll} v(\phi) = 0 & & \\ v(R) = -4.4 & v(C) = -4 & v(L) = -1.43 \\ v(CL) = 4.4 & v(RL) = 4 & v(RC) = 1.43 \\ & v(RCL) = 0 & \end{array}$$

- What happens if the players refuse to play the game?
- ϕ is the null set. By convention the value of the null set is zero.

1. Set Theory and Conventions

- i : an index on players, who number 1 to n
- S : Any coalition, including coalitions of one player or null players
- N : The coalition of all coalitions; the supercoalition
- $A \cap B$: intersection; coalitions in A and B
- $A \cup B$: union; coalitions in A or B
- $A \setminus B$: relative complement; coalitions in A not B

2. Set Theory and Conventions

- \emptyset : The set containing no members
- \in : is a member of
- $v()$: The value operator; takes any set and delivers the value, a quantity describing the payoffs accessible to that coalition

Definition of an N-Person Prisoner's Dilemma

- Each of n players has the choice of strategies C and D (consider them as cooperate and defect).
- For every player, D is a dominant strategy, and
- If all players choose D, all will be worse off than if all players had chosen C

Tragedy of the Commons

- Influential 1968 article in *Science* by Garrett Hardin
- An n-person Prisoner's Dilemma
- Farmers individually have the incentive to overgraze even though all are worse off
- 1833 pamphlet from William Forster Lloyd, Oxford professor of political economy
- Based on medieval land tenure



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Common Pool Resources

- Continuing modern relevance
- Include forests, fisheries, oil and coal fields, grazing lands, irrigation and water systems
- Also relevant to technologies with negative externalities
- These include passenger vehicles including congestion, carbon emission, and increasing likelihood of accident



Jungle burned for agriculture in southern Mexico (Lacanja, Chiapas). Picture released in public domain by Jami Dwyer.

What Hardin Suggested

- Hardin suggested “mutual coercion mutually agreed upon”
- What Hardin is thought to have suggested is “privatizing the regulated commons”
- The privatization proposal is controversial because
 - Many local communities do effectively manage common resources
 - Re-appropriation can disenfranchise local poor and minorities
 - It is seen as an expression of global capitalist ideology

Elinor Ostrom

- Continuing commentary on common pool resources
- Winner of the 2009 Nobel Prize in Economics
- Part of the “Invisible College” of TBM
- There are multiple ways of dealing with these socio-ecological systems
- Studied successful local management systems



Elinor Ostrom during Nobel Prize press conference 2009. © Prolineserver 2010, Wikipedia/Wikimedia Commons (cc-by-sa-3.0)

Institutional Analysis and Design

Design principles derived from study

1. Clearly defined boundaries
2. Rules regarding appropriation are adapted to local conditions;
3. Collective-choice arrangements allow appropriators to participate
4. Effective and accountable monitoring
5. Scales of graduated sanctions for resource violation
6. Mechanisms of conflict resolution are cheap and of easy access
7. Self-determination of the community recognized by others
8. Organization in hierarchical layers as necessary

Do People Behave As Selfishly as Suggested?

- Ostrom agrees, but only in limited cases:
“[the dilemma] applies to situations where there is so much distrust, and communication is so costly, and people see so little benefit to solving environmental problems that they are, effectively, trapped.”
- However there are real dilemmas concerning common pool resources:
"There is a huge body of literature that documents where people have overcome these CPR problems. Some of that literature is a little naive and romantic, so I think what we state ... is important.' There are all sorts of puzzles and problems, and we point to some of the more difficult ones."

Quotes from <http://www.iuinfo.indiana.edu/HomePages/041699/text/ostrom.htm>

Richer Models of Cooperation are Needed

- We know that cooperation can be sustained in the prisoner's dilemma when
 - The game is repeated
 - Given the beliefs of the players
 - Given network or spatial structuring to the problem