



Tragedy of the Commons

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Overview

- What is tragedy of the commons?
- Leviathan
- Privatization
- Self governing examples/principles
- Experimental cooperation
- Next steps



Term definitions

Excludability: Ability to prevent consumers who don't pay from accessing a good (eg. most consumer goods)

Externality: Cost or benefit that affects a party without their input (eg. air pollution)

Free Rider problem: Benefit from public good without paying for it (eg. research)



Hardin (1968)/Forster Lloyd (1833)

- “Freedom in a commons brings ruin to all.”
- A field is shared amongst herders
- Each herder is incentivized to graze as many sheep as possible on the field
- If too many sheep graze on that field, the field is overgrazed and cannot graze any sheep in the future



Hardin (1968) cont'd

- Argued that without restriction of the commons, tragedy was inevitable
- “The only way we can preserve and nurture other and more precious freedoms is by relinquishing the freedom to breed, and that very soon”



Formalization

- Given a field that can support L animals and 2 herders, each herder should graze $L/2$ animals


	Cooperate	Defect
Cooperate	10, 10	-1, 11
Defect	11, -1	0, 0



Leviathan

- Large outside force to coerce the participants
- Leviathan must know L and when someone defects
- Costs of monitoring are not considered

	Cooperate	Defect
Cooperate	$10-2x, 10-2x$	$-1-2x, 11-2y$
Defect	$11-2y, -1-2x$	$-2y, -2y$



Privatization (Smith, 1981)

- Split the field in 2
- Each player plays against nature, will graze the optimal amount of animals
- Field cannot always be allocated evenly, or allocated at all (how do you allocate the ocean?)



Governing the Commons (Ostrom, 1990)

- Demonstrated that tragedy of the commons is not inevitable
- Agents can make a binding contracts for a cooperative strategy without the use of leviathan or privatization
- Nobel prize in 2009 for her work



Alanya Fisheries

- List of eligible fishers is prepared (including those outside the co op)
- All usable fishing spots listed and named
- Fishers draw lots and are assigned a location (September to May)
- Every day, each fisher moves east to the next location. After January, fishers move west
- Violations are punished by the group collectively



Huerta Irrigation Systems: Valencia

- Three environmental conditions: Abundance, seasonal low water, drought
- The water rotates in turns
- Farmer can take as much water as he needs, but cannot waste water
- If water runs out, then irrigation continues from where it left off
- If he misses his turn, he must wait until the next rotation
- During drought, crops that most need water are given priority
- Recorded infraction rate of 0.8%

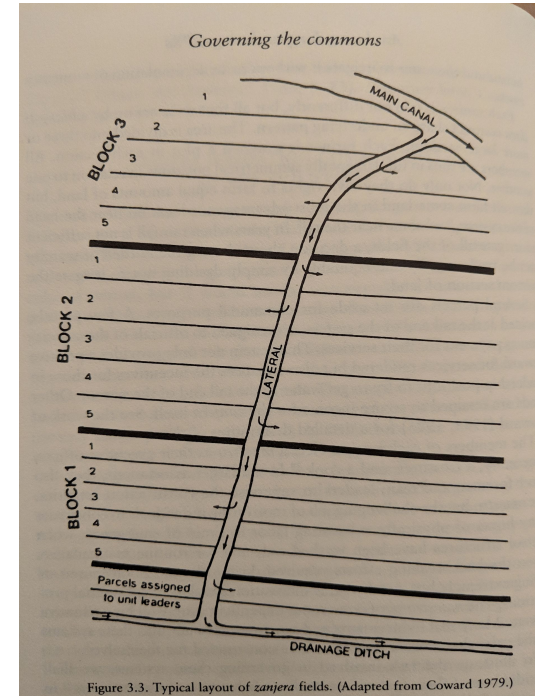


Huerta Irrigation Systems: Murcia/Orihuela

- Lower average rainfall/higher variation than in Valencia
- *Tanda*, time period which farmer can withdraw water
- If low water conditions are in effect (determined by officials) a schedule is posted for the upcoming rotation that lists crops that are given precedence

Zanjera fields, Philippines

- Self maintained irrigation system
- Farmers are assigned a plot in each block
- In times of drought, the lower blocks are not irrigated





Torbel, Switzerland

- Villagers tend to their own crops on privately owned plots
- Cattle are grazed on communally owned meadows by herdsmen
- Villagers are not allowed to send more cows than they are able to winter
- Enforcement by official who keeps half the fines for himself
- Payments for maintenance, capital expenses proportional to number of cattle sent



Principles of long enduring CPR institutions

1. Clearly defined boundaries
2. Congruence between appropriation and provision rules/local conditions
3. Collective Choice Arrangements
4. Monitoring



Design principles cont'd

1. Graduated sanctions
2. Conflict resolution mechanisms
3. Minimal recognition of rights to organize
4. Nested enterprises



Contract Theory (Hart, 1995)

- Incomplete contracts: No contract can specify every case
- Incomplete information for each agent
- Cost of maintaining the contract must be less than the benefits to the agents



Mason and Phillips (1997)

- **Cournot equilibrium:** each firm is producing at what maximizes its profits given what other firms produce
- 2-5 firms competing against each other
- Simulate firm's harvest costs to compute each firm's payoff,
- Choices and payoffs visible to all participants

Static Externality

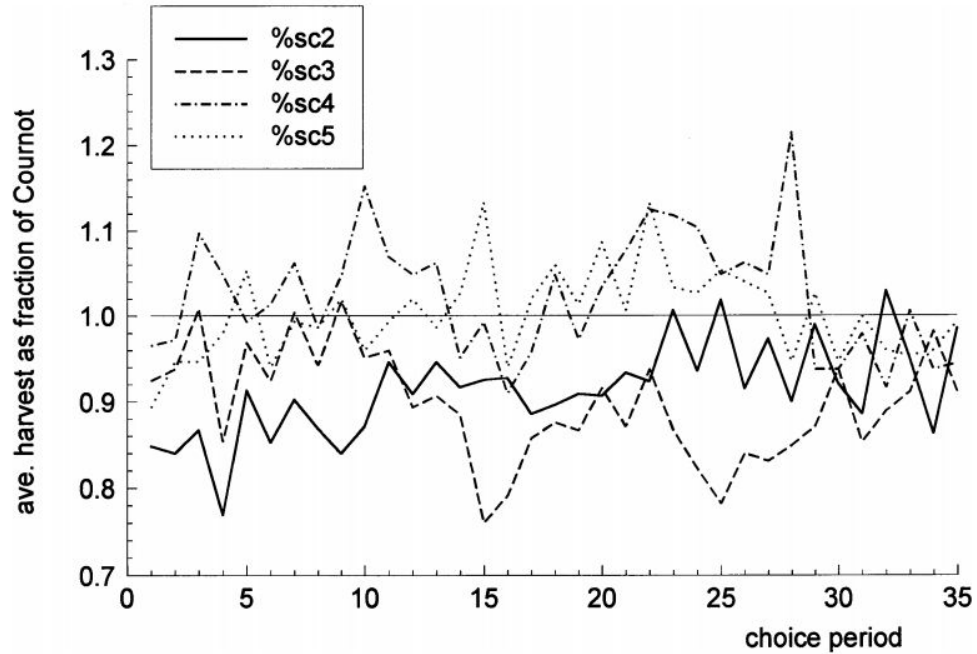


FIG. 1. Static externality markets.

Dynamic Externality

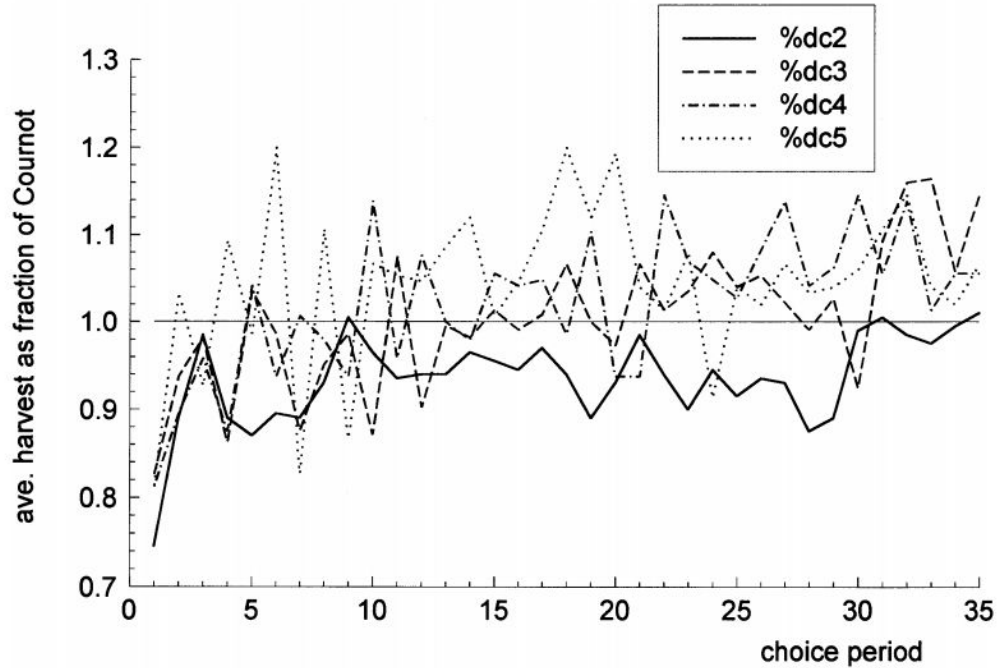


FIG. 2. Dynamic externality markets.



Mason and Phillips (1997) cont'd

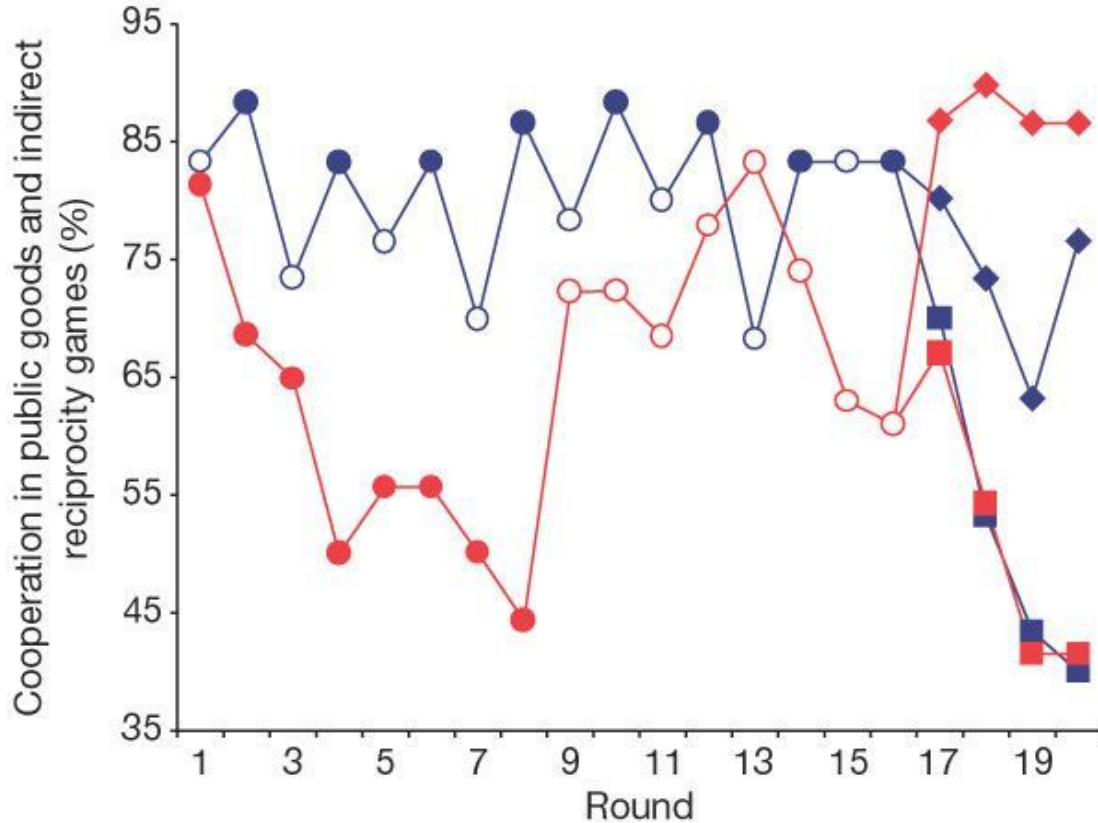
- Cooperation increases number of firms with static externalities
- Dynamic externalities (cost of harvest linked to the resource stock) does not



Milinski et al (2002)

- Alternate between public goods game and indirect reciprocity game
- Public goods game: all players put in money, payout is $2A/n$
- Indirect Reciprocity game: does player A want to give X dollars to player B? Decision is broadcasted
- Player A will never be the recipient of player B if they are already the donor

Milinski results



- filled symbols indicate public goods game, open indirect reciprocity
- Squares indicate players knew that remaining games were public goods, diamonds they did not



Milinski et al (cont'd)

- Authors conclude that reputation has an effect on the degree of cooperation
- Barclay (2004) extends this experiment by playing a trust game; send X dollars, get Y back. Participants could *choose who to send money to*



Next Steps/Future Questions

What is the difference between CPR systems that work and those that don't? What design principles need to hold?

- time scale. Given enough time, will agents converge towards cooperation?
- "altruism towards future self": does restricting/expanding the time horizon affect whether agents act cooperatively?
- Link between fairness and the Free Rider Problem
- Some work has been done on Dunbar's number (Ducheneaut et al.) in online games



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