Session 17 – Prisoners' Dilemma and Collective Action

C17.1 Intro: The Prisoners' Dilemma & Collective Action

P1 \ P2	C	D
C	4,4	0,6
D	6,0	2,2

Arms Races
Price Competition
Technology Adoption
Negative Campaigning
Food Sharing
Hedonic Treadmills

Cooperate 7 Ways in PD, Collective Action, Common Resource Problems, No Panacea. Five modes of cooperation come from the natural world (species and body components cooperation). Two are human induced (ways to get cooperation as in the Prisoner's Dilemma).

Quiz: Collectively, agents in a prisoners' dilemma are better off if they... (a) Defect, (b) Cooperate
Ans: (b) collectively cooperate; (individually defect).

Collective Action:

- Extension of Prisoner's Dilemma from two people to a 'collection' of people.
- Operative question: How much can you contribute to something?
- Insight – the tendency to free ride

Common Pool Resource Problems:

- Inverse of collective action problem.
- Resources like trees, water, air, common pasture, lobster
- How many can you harvest? The more you harvest the more you are defecting.
- Group better off with harvest management, but individually you're better off being greedy.

No Panacea: Elenor Ostrom (asu.edu) Nobel in Economics – addressed how do people solve these collective action problems and these common pool resource problems?

Quiz: Individually, agents in a prisoner's dilemma are better off if they... (a) Cooperate, (b) Defect
Ans: (b) Defect

Outline: Talk about Prisoners' Dilemma and Cooperation. Follow that with Collective Action and Common Pool Resource Problems and a bit about how to solve those group problems.

C17.2 The Prisoners' Dilemma Game

Prisoners' Dilemma:

- Collectively better to Cooperate (4,4)
- Individually better to Defect (2,2), avoids (6,0) & (0,6)

P1 \ P2	C	D
C	4,4	0,6
D	6,0	2,2

Repetitive Prisoners' Dilemma:

- Multiple plays offers alternating (C,D) and (D,C) for $mean = 4.5 > 4$
- Weak Alternation

P1 \ P2	C	D
C	4,4	0,9
D	9,0	2,2

PD Formal Description:

- $T > R > 0$
- $F > T$
- $2T > F$ (to avoid alternating)

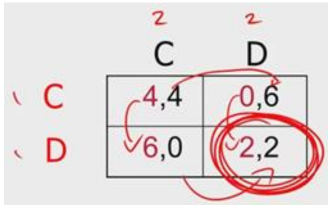
P1 \ P2	C	D
C	T,T	0,F
D	F,0	R,R

Pareto Efficient:

- No way to make anyone better off. True for (4,4), (6,0), & (0,6)
- (2,2) is not Pareto Efficient. Can make everyone better off by going to (4,4).

Nash Equilibrium:

- NE: What people seem to optimize.
- (2,2) is NE. D dominates for P1 & P2.



Observation:

- (4,4), (0,6), (6,0) are efficient (Pareto) but not optimal
- (2,2) is optimal but not efficient.
- PD illustrates that our social preferences don't always align with the incentive (equilibrium) way people behave.
- PD: Individual preference go one way, social preferences go another way

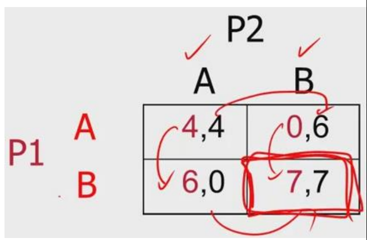
Quiz: Which of the following is a rule of the prisoners' dilemma game? Check any that apply. (a) Collectively, agents are better off cooperating than defecting. (b) Player 1 is better off defecting if Player 2 cooperates (and vice-versa). (c) Players are better off alternating than coordinating. (d) The payoffs to cooperating and to defecting must both be greater than

Ans: (a), (b), (d)

Explanation: *Go back to 3:18 (time) in the lecture for the formal definition of a prisoners' dilemma game.*

Self Interest Game:

- Pareto efficient is also equilibrium.



Examples:

Arms Control: C = Education, D = Bombs

Price Competition: C = High Prices, D = Low Prices
(companies compete, consumers benefit)

Technology Adoption: C = No ATM, D = ATM
(Banks installing ATMs, greater profits if C; actual result is (D,D))

Quiz: Imagine a Prisoner's Dilemma in which both players defect. Which one of the following characterizes this outcome? (a) This outcome is Pareto Efficient. (b) This outcome is a Nash Equilibrium.

Ans: (b) standard PD, Nash Equilibrium

Explanation: *By definition, the (defect, defect) scenario in a Prisoner's Dilemma is not Pareto Efficient, since we can imagine an outcome (cooperate, cooperate) that would be more beneficial to both players.*
However, if both players defect, it is a Nash Equilibrium, since the best move for each player based on the best move for the other player leads both players to defect.

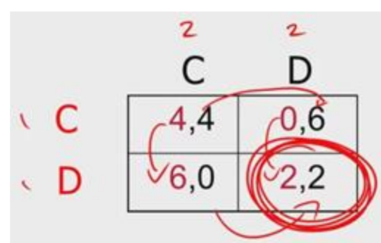
More Examples:

Political Campaigns:
C = Positive Ads, D = Negative Ads

Food Sharing: C = Share, D = Don't Share

Hedonic Treadmills:
C = Digital Watch, D = Hand Made Watch (want to look coolest, both spend, neither stands out)

PD Result is an outcome that is not efficient.



C17.3 Seven Ways to Cooperation

Prisoners' Dilemma:

- Collectively better to Cooperate (4,4)
- Individually better to Defect (2,2), avoids (6,0) & (0,6)

P1 \ P2	C	D
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Another View of the Prisoners' Dilemma.
Cost of cooperation: **c** versus the
Benefit to other(s): **b**
Where **b > c,** i.e., individuals prefer to defect whereas socially it's better for everyone if/when everyone cooperates
Captures PD essence. Individually (defect) Socially (cooperation is preferred)

Martin Nowak "Super Cooperators" Harvard: Natural 5 ways

1. Repetition, or Direct Reciprocity (e.g., tit-for-tat)

p = probability we <u>meet again</u>.
Payoffs: Deviate: 0, Cooperate: $-c + pb$,
($-c$ is cost now, pb is pay later when meet again). Thus if $-c + pb > 0 \quad if\ p > c/b$, then should cooperate.

Repetition: Move from LA to Iowa

LA vs Iowa: Why would lady in queue let me go ahead of them. Logic of meeting again (repeated encounters & payoffs).
Example:
Iowa City: Benefit = 10, Cost = 2, c/b = 1/5

LA: p ~ 1/1000, Iowa City p ~ 0.5 more likely to cooperate for higher average payoff.

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2. **Reputation (Indirect Reciprocity)**: The advantage of maintaining a good reputation.

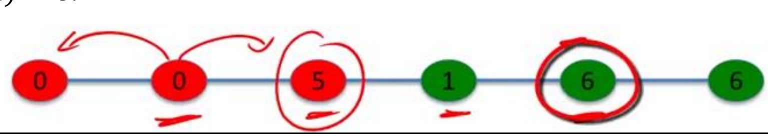
q = probability that reputation is known. Payoffs = Deviate = 0, Cooperate: -c + qb
$-c + qb > 0 \quad q > c/b$

NETWORK INSIGHTS ON COOPERATION

3 – Network Reciprocity:

{Use Python indexing for P, [0, n] }
P2(red) is getting 5 by defecting. P3(green) is getting (5-2) + (0-2) = 1, and P4(green) is getting (5-2)+(5-2)=6. P3 perceives he may get 6 as opposed to 5 by cooperating so is inclined to cooperate.

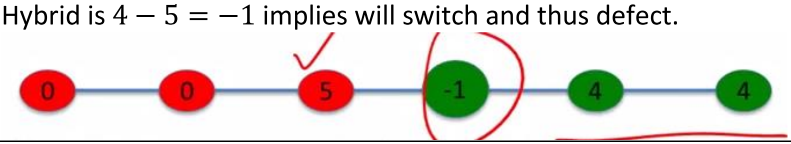
Regular Graph (everyone has same number of neighbors).
Given k neighbors, if $\boldsymbol{k} < \boldsymbol{b}/\boldsymbol{c}$, cooperation is likely.
Benefit of Cooperation: **B =5**, Cost of Cooperation: **C=2**,
Neighbors: **K=2**. Red ➔ defector, Green ➔ cooperator
Defector surrounded by defectors payoff is 0. Note hybrid $(6 - 5 = 1)$
Cooperator surrounded by cooperators payoff is$(5 - 2) + (5 - 2) = 6$.



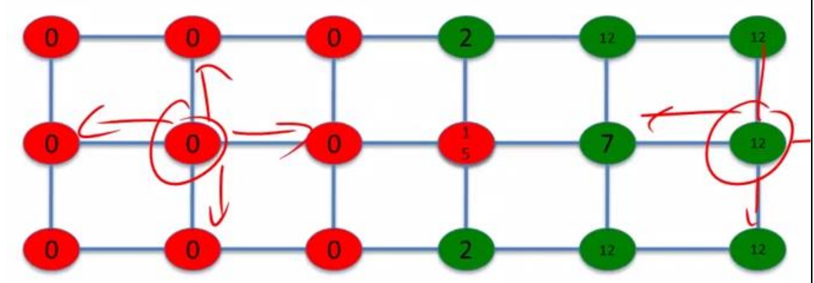
New Payoffs:

Now P3(green) sees a payoff of 4 for cooperating and a potential payoff of 5 from defection while his current cooperation is just paying
(5-3)+(0-3)=-1. Thus is likely to choose to defect.

Benefit of Cooperation: **B =5**, Cost of Cooperation: **C=3**,
Neighbors: **K=2**. Red ➔ defector, Green cooperator
Defector surrounded by defectors payoff is 0.
Cooperator surrounded by cooperators payoff is$(5 - 3) + (5 - 3) = 4$.
Hybrid is $4 - 5 = -1$ implies will switch and thus defect.



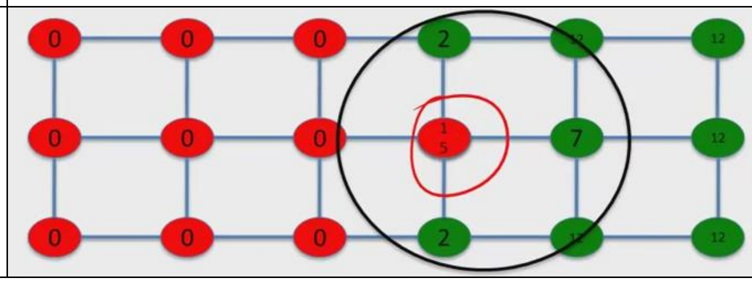
K = 4 Model: Benefit of Cooperation: **B =5**, Cost of Cooperation: **C=2**, Neighbors: **K=4**. Notes:
(a): P(1,1)(red) has payoff 4(0) = 0.
(b): P(5,1) is getting 4(5-2) = 12. P(4,1) is 3(5-2) + (0-2) = 7, and P(3,1)(red) gets 3(5-0) + (0) = 15 for defecting.
Thus P(4,1) is inclined to defect.



***Bottom line: More Connectedness more likelihood to defect*.**

Why k<b/c:

Defector stickiing out gets 5 from 3 cooperators.



k neighbors: payoffs:
Surrounded by Cooperator U = k(b-c)
Boundary Defector U = (k-1)b
k(b-c) > (k-1)b b > kc b/c > k or in words
The (Benefit of Cooperation)/(Cost of Cooperation) must be greater than the number (k) of neighbors to choose cooperation.

Network Reputation: Denser ties (clusters and network connections) make reputation-driven decisions more likely to increase reputation and thus cooperation.

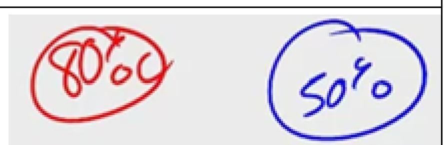
Network Reciprocity: Denser ties makes the influence of defectors stronger on decisions to defect or cooperate. Denser ties reduce cooperation.

GROUP SELECTION AND COOPERATION

Within Group:
Defectors will do better.

Between Groups: Groups that have more cooperators will win more wars.

Competition and Cooperation:
Assume Red group has 80% cooperators and Blue group has 50% cooperators. If they go to war, the Red group is likely to prevail over the Blue group. Note: Defectors within groups will do better but when in conflict with another group, the group with more cooperators has a winning edge.



5 - KIN SELECTION AND COOPERATION

Players are related and you care about other people based on their relatedness, $\boldsymbol{r}$. An example of $\boldsymbol{r}$ is say (r = 0.5) for an offspring. Cooperation ensues when $\boldsymbol{rb} > \boldsymbol{c}$ where $\boldsymbol{b}$ and $\boldsymbol{c}$ are as above. Say $b = 10$, $r = 0.5$, and $c = 2$, then is $\boldsymbol{rb} > \boldsymbol{c}$? This model is often used in ecology.

Quiz: Of the five ways to produce cooperation that we have just reviewed, which is/are the MOST, likely to explain why people in small, isolated, towns are so nice? (a) Group Selection, (b) Network Reciprocity, (c) Reputation (Indirect Reciprocity), (d) Repetition (Direct Reciprocity)
Ans: (c) and (d)
Explanation: *Both Repetition and Reputation explain why people would be nice in a small town - because p and q are high, meaning that there is a high probability in small towns that two people will meet again and that one's reputation will spread. Group reciprocity is less likely, since small isolated towns are unlikely to be competing (or fighting) with surrounding towns. Network Reciprocity is also less likely to explain this, because it suggests that the more dense the connections between people, the more likely people are to observe the people around them who do better then them by defecting with cooperators, which leads them to change to defect.*

HUMAN SOCIETY AND COOPERATION

1 – Laws and Prohibitions: Can just make things illegal	**2 – Incentives:** Increase the costs of not compling. Shoveling snow fine if you didn't remove your sidewalk snow.

SUMMARY:
(1) Repeated Interactions (direct reciprocity), (2) Reputation (indirect reciprocity), (3) Networks, (4) Group Selection Influence, (5) Kin Selection, (6) Laws (prohibitions), and (7) Incentives (fines, fees, and subsidies).

C17.4 Collective Action and Common Pool Resource Problems

Extending the Prisoner's Dilemma to n Players:
Collective Action: Cost to me if I take action, yet a benefit to all.

Note if $\beta > 1$, then there is always a higher payoff to cooperate.

Let x_j be the action of person P_j where effort $x_j \in [0, 1]$
where assume $\beta \in (0, 1)$ & cost of action is x_j

$$Payoff\ to\ j = -x_j + \beta \sum_{i=1}^{N} x_i$$

Note:
if $\beta > 1$, P_j is assured net benefit, N is total persons
The $\beta \sum x_i$ term is the benefit of cooperation.

Quiz: True or False: The fundamental difference between prisoners' dilemma games and collective action problems is that - while there are only two players in a prisoners' dilemma game - there are more than two parties in a collective action problem. (a) True, (b) False
Ans: (a) True

Payoff to j = $-x_j + 0.6\sum_{i=1}^{N} x_i$

x_1 $x_2 = x_3 = x_{10} = 1$

$x_1 = 0 = 0 + .6(9) = 5.4$

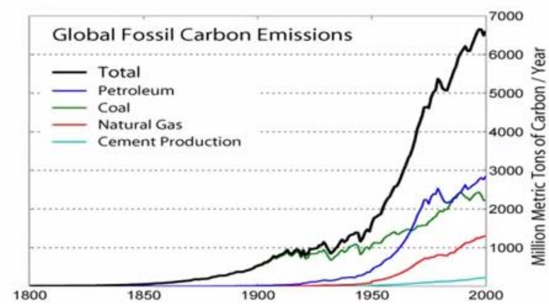
$x_1 = 1 = -1 + .6(10) = 5$

Example:
Assume 10 people with cooperation payoff = 1 and defection payoff = 0 for everyone and $\beta = 0.6$. If x_1 defects his payoff is 5.4 but if cooperates his payoff is 5.0 so it is his advantage to defect to the expense of his colleagues.

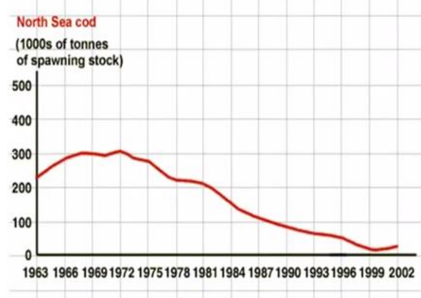
Quiz: Imagine a collective action problem with 30 players. If you choose to cooperate (meaning Xj=1), and so do 15 others, what is your payoff? Assume $\beta = 0.7$
Analysis: $-x_j + \beta \sum_{i=1}^{N} x_i = -1 + 0.7(16) = 11.2 - 1 = 10.2$
Ans: 10.2
Explanation: *Remember our equation:* $Payoff\ to\ j = -x_j + \beta \sum_{i=1}^{N} x_i$
We set β equal to 0.7 and solve: Payoff = −1+0.7(16)=10.2
In the above equation, 16 represents everyone who cooperates (you and 15 others). The −1 is your cost of cooperating. ***So your payoff in this scenario is 10.2.***

Collective Action Problem:
(Sometimes called Free Rider problems)
Carbon Emissions

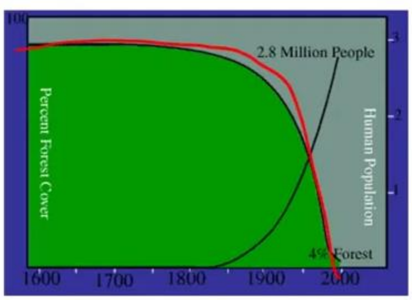
Carbon Emissions:



Common Pool Resource Problem:

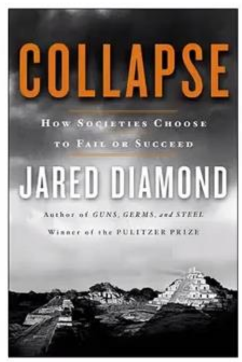


North Sea Cod



x_j amount consumed by j
X is total consumed
Amount for next period (t+1)

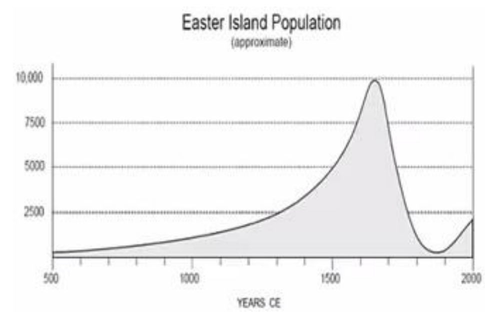
$$C_{t+1} = (C_t - X)^2$$



🡐 **Phillipenes forests & Population**

Cod Example:
Let $C_1 = 25$, $X_1 = 20$, then
$C_2 = (25-20)^2 = 25$ and stock is sustained.
But if increase consumption to $X_1 = 21$,
Then $C_2 = (25-21)^2 = 16$ and stock erodes.

Easter Island



Easter Island collapse when forest was completely destroyed. Same resource depletion in Phillippenes but can trade with others for loss of forest resources.

Common Resource Problem solutions depend upon the specifics / particulars of the issue. Particulars are going to matter.

C17.5 No Panacea

Our simple models of **collective action** or **common pool resources** overlook a number of particulars that are important to solve the problem.	**Collective Action**: Want people to contribute **Common Pool**: Want to preserve resources in a sustainable way.

Quiz: Pretend that you're driving on the highway and you see a chair in the middle of the road. You had to turn out of the way to avoid hitting the chair with your car. You consider stopping your car, getting out, and moving the chair out of the way. On the other hand, you're late to work, and it's not your fault that the chair is in the road. You have to figure whether to move the chair or not. This is an example of which situation? (a) A prisoner's dilemma game, (b) A collective action problem, (c) A common pool resource problem, (d) None of the above

Ans: (b) A collective action problem

Explanation: *The dilemma here can be summarized by saying: "it's in my interest to leave the chair in the road, but collectively we'll all be better off if I move the chair out of the road." This is a collective action problem in which most people in the real world choose to defect.*

Do we need to know more?
Collective Action $Payoff\ to\ j = -x_j + \beta \sum_{i=1}^{N} x_i$ and **Common Pool Resource** $C_{t+1} = (C_t - X)^2$ are simplifications. Once we know the problem based on the model insights, how do we apply in the real world?

Elenor Ostrom: Nobel Prize Winner (political scientist) who looked all the different ways people had tried to solve these problems. *She was awarded the 2009 Nobel Memorial Prize in Economic Sciences, which she shared with Oliver E. Williamson, for **"her analysis of economic governance, especially the commons."** Her work is associated with the new institutional economics and the resurgence of political economy. Wikipedia*

The Commons: Cattle Grazing versus **Lobster Fishing**
Rotation Schemes: Can the resource continuously observable so it can be monitored? Branding and rotation for Cattle Grazing on Common. Grassland is more observable than lobster population. Need other monitoring mechanisms to effectively monitor the lobster population.
Stream flow use: The person who is up steam is more significant in management of the commons than the downstream person.
The particulars are important in each of these cases.

Design Principles for CPR institutions:
Ostrom identifies eight "design principles" of stable local common pool resource management:

- Clearly defined boundaries (effective exclusion of external un-entitled parties);
- Rules regarding the appropriation and provision of common resources that are adapted to local conditions;
- Collective-choice arrangements that allow most resource appropriators to participate in the decision-making process;
- Effective monitoring by monitors who are part of or accountable to the appropriators;
- A scale of graduated sanctions for resource appropriators who violate community rules;
- Mechanisms of conflict resolution that are cheap and of easy access;
- Self-determination of the community recognized by higher-level authorities;
- In the case of larger common-pool resources ,organization in the form of multiple layers of nested enterprises, with small local CPRs at the base level.

The above principles have since been slightly modified and expanded to include a number of additional variables believed to affect the success of self-organized governance systems, including effective communication, internal trust and reciprocity, and the nature of the resource system as a whole.

Ostrom and her many co-researchers have more recently developed a comprehensive "Social-Ecological Systems (SES) framework", within which much of the still-evolving theory of common-pool resources and collective self-governance is now located.

Work with Environmental Protection
"Ostrom cautions against single governmental units at global level to solve the collective action problem of coordinating work against environmental destruction. Partly, this is due to their complexity, and partly to the diversity of actors involved. Her proposal is that of a polycentric approach, where key management decisions should be made as close to the scene of events and the actors involved as possible."