PHIL309P
Methods in Philosophy, Politics and Economics

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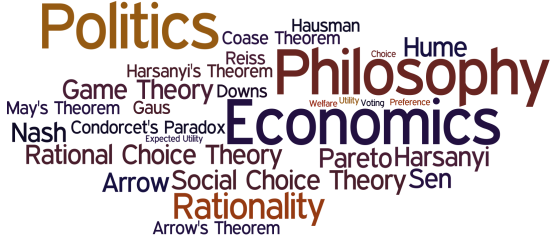

Prisoner's Dilemma

Ann \ Bob	C	D
C	3,3	1,4
D	4,1	2,2

Iterated Prisoner's Dilemma

	C	D
C	3,3	0,4
D	4,0	1,1

	C	D
C	3,3	0,4
D	4,0	1,1

	C	D
C	3,3	0,4
D	4,0	1,1

	C	D
C	3,3	0,4
D	4,0	1,1

$\cdots$

Iterated Prisoner's Dilemma

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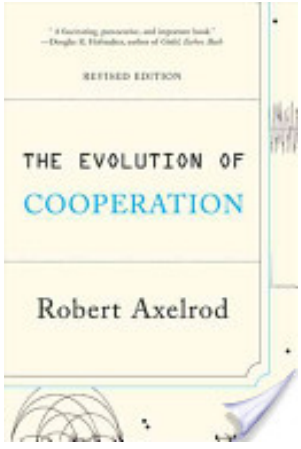
REVISED EDITION
THE EVOLUTION OF
COOPERATION
Robert Axelrod

Strategies

- Periodic: All-C, All-D, CD, CCD, CDD, CCDD, ...
- Random
- Memory: Tit-for-Tat, Two-Tit-for-Tat, ...

	C	D
C	3,3	0,4
D	4,0	1,1

	C	D
C	3,3	0,4
D	4,0	1,1

	C	D
C	3,3	0,4
D	4,0	1,1

	C	D
C	3,3	0,4
D	4,0	1,1

...

Additional Reading

- S. Kuhn, Prisoner's Dilemma, Stanford Encyclopedia of Philosophy, plato.stanford.edu/entries/prisoner-dilemma/

- W. Poundstone, Prisoner's Dilemma, Anchor, 1993

Why *should* players play a Nash equilibrium?

Mixed Strategies

"We are reluctant to believe that our decisions are made at random. We prefer to be able to point to a reason for each action we take. Outside of Las Vegas we do not spin roulettes."

A. Rubinstein. *Comments on the Interpretation of Game Theory*. Econometrica 59, 909 - 924, 1991.

Mixed Strategies

- One can think about a game as an interaction between large populations...a mixed strategy is viewed as the distribution of the pure choices in the population.

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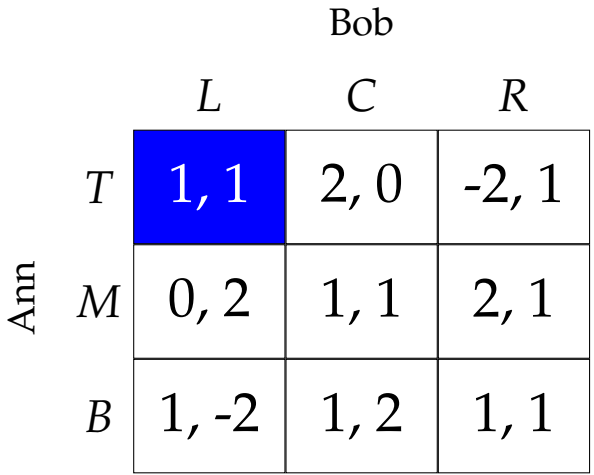
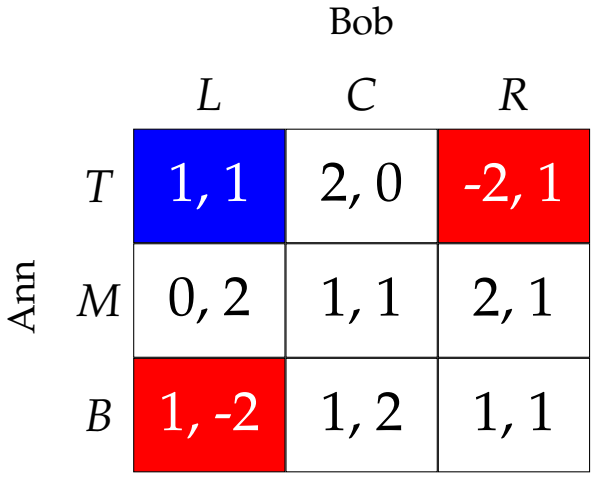
- *Harsanyi's purification theorem*: A player's mixed strategy is thought of as a plan of action which is dependent on private information which is not specified in the model. Although the player's behavior appears to be random, it is actually deterministic.

- Mixed strategies are beliefs held by all *other* players concerning a player's actions.

		Bob		
		L	*C*	*R*
Ann	*T*	1, 1	2, 0	-2, 1
	M	0, 2	1, 1	2, 1
	B	1, -2	1, 2	1, 1



(T, L) is the unique pure-strategy Nash equilibrium



(T, L) is the unique pure-strategy Nash equilibrium

Ann \ Bob	L	C	R
T	1, 1	2, 0	-2, 1
M	0, 2	1, 1	2, 1
B	1, -2	1, 2	1, 1

Why not play B and R?

Why play Nash equilibrium?

Self-Enforcing Agreements: Nash equilibria are recommended by being the only strategy combinations on which the players could make self-enforcing agreements, i.e., agreements that each has reason to respect, even without external enforcement mechanisms.

M. Risse. *What is rational about Nash equilibria?*. Synthese, 124:3, pgs. 361 - 384, 2000.

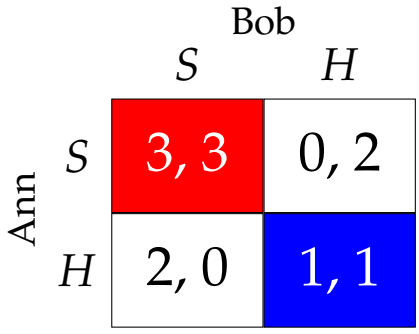
Ann \ Bob	L	R
U	3, 3	1, 4
D	4, 1	2, 2

Can Ann and Bob **agree** to play U, L?

Stag-Hunt

Ann \ Bob	S	H
S	3, 3	0, 2
H	2, 0	1, 1

Stag-Hunt



(S, S) and (H, H) are Nash equilibria

Stag-Hunt

Ann \ Bob	S	H
S	3, 3	0, 2
H	2, 0	1, 1

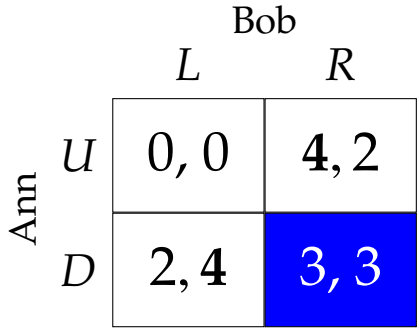
(S, S) is Pareto-superior, but (H, H) is less risky

Ann \ Bob	L	C	R
T	4, 6	5, 4	0, 0
M	5, 7	4, 8	0, 0
B	0, 0	0, 0	1, 1

Ann \ Bob	L	C	R
T	4, 6	5, 4	0, 0
M	5, 7	4, 8	0, 0
B	0, 0	0, 0	1, 1

(B, R) is a Nash equilibrium, but it is **not self-enforcing**

Ann \ Bob	L	R
U	0, 0	4, 2
D	2, 4	3, 3



(D,R) is self-enforcing, but **not a Nash equilibrium**

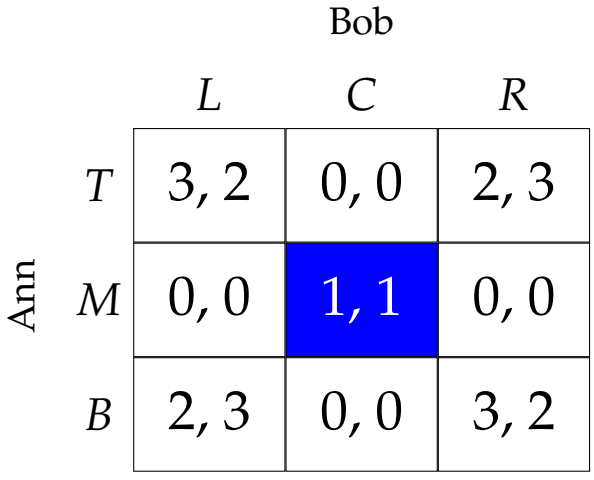
Self-Enforcing Agreements: Nash equilibria are recommended by being the only strategy combinations on which the players could make self-enforcing agreements, i.e., agreements that each has reason to respect, even without external enforcement mechanisms.

- Not all Nash equilibria are "equally" self-enforcing
- There are Nash equilibria that are not self-enforcing
- There are self-enforcing outcomes that are not Nash equilibria

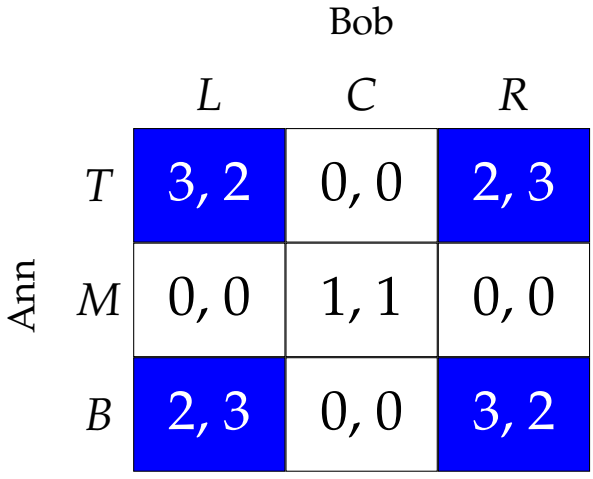
Playing a Nash equilibrium is *required* by the players rationality and *common knowledge* thereof.

- Players need not be *certain* of the other players' beliefs
- Strategies that are not an equilibrium may be *rationalizable*
- Sometimes considerations of riskiness trump the Nash equilibrium

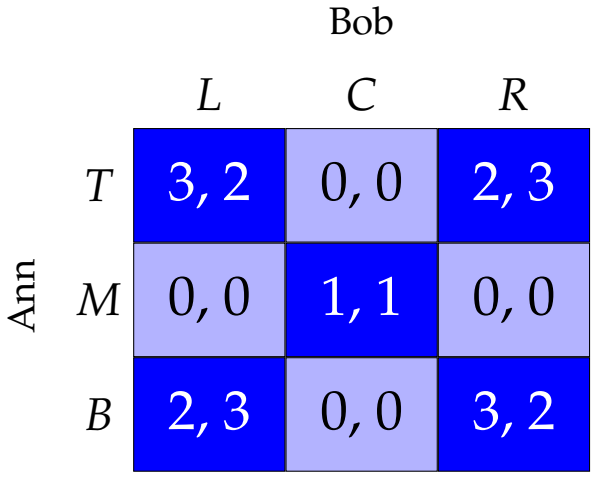
Ann \ Bob	L	C	R
T	3, 2	0, 0	2, 3
M	0, 0	1, 1	0, 0
B	2, 3	0, 0	3, 2



(M, C) is the unique Nash equilibrium



T, L, B and R are **rationalizable**



T, L, B and R are **rationalizable**

Ann \ Bob	L	C	R
T	3, 2	0, 0	2, 3
M	0, 0	1, 1	0, 0
B	2, 3	0, 0	3, 2

Ann plays B because she thought Bob will play R

Ann \ Bob	L	C	R
T	3, 2	0, 0	2, 3
M	0, 0	1, 1	0, 0
B	2, 3	0, 0	3, 2

Bob plays L because she thought Ann will play B

Ann \ Bob	L	C	R
T	3, 2	0, 0	2, 3
M	0, 0	1, 1	0, 0
B	2, 3	0, 0	3, 2

Bob was correct, but Ann was wrong

		Bob			
		L	*C*	*R*	*X*
Ann	*T*	3, 2	0, 0	2, 3	0, -5
	M	0, 0	1, 1	0, 0	200,-5
	B	2, 3	0, 0	3, 2	1,-3

Not every strategy is rationalizable: Ann can't play *M because* she thinks Bob will play *X*

"Analysis of strategic economic situations requires us, implicitly or explicitly, to maintain as plausible certain psychological hypotheses. The hypothesis that real economic agents universally recognize the salience of Nash equilibria may well be less accurate than, for example, the hypothesis that agents attempt to "out-smart" or "second-guess" each other, believing that their opponents do likewise." (pg. 1010)

B. D. Bernheim. *Rationalizable Strategic Behavior*. Econometrica, 52:4, pgs. 1007 - 1028, 1984.

"The rules of a game and its numerical data are seldom sufficient for logical deduction alone to single out a unique choice of strategy for each player. *To do so one requires either richer information (such as institutional detail or perhaps historical precedent for a certain type of behavior) or bolder assumptions about how players choose strategies.* Putting further restrictions on strategic choice is a complex and treacherous task. But one's intuition frequently points to patterns of behavior that cannot be isolated on the grounds of consistency alone." (pg. 1035)

D. G. Pearce. *Rationalizable Strategic Behavior*. Econometrica, 52, 4, pgs. 1029 - 1050, 1984.