Pieter Bruegel the Elder: Children’s Games (1560)

Evolutionary Game Theory

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FTP server with downloadable lecture .ppts

Exam

Instead of a traditional oral exam, the evaluation of your knowledge will be based on the solved problems (at the end of each lecture .ppt file). I will ask you to send me your solutions via e-mail to kiraly.balazs@ek.hun-ren.hu. After checking your solutions (the more, the better), I will recommend a mark that can be improved in an oral exam that takes the form of a discussion about the main message of a topic selected from this list:

- basic concepts of game theory
- social dilemmas, experiments (Axelrod, etc.)
- stochastic reactive strategies
- population dynamics, evolutionarily stable solutions
- potential games
- decomposition of matrix games
- spatial evolutionary games
- evolutionary games on networks
- three-strategy games, rock-paper-scissors game
- competing associations

Don't hesitate to write me, if you have further questions.

Literature:

Nowak: Evolutionary Dynamics (Harvard University Press, 2006)

Sigmund: The Games of Life, (Oxford University Press. 1993)

Sigmund: The Calculus of Selfishness (Princeton University Press, 2010)

Axelrod: The Evolution of Cooperation (Basic Books, 1984)

Hofbauer and Sigmund: Evolutionary Games and Population Dynamics (Cambridge University Press, 1998, online 2012)

Gintis: Game Theory Evolving (Princeton University Press, 2009)

Cressman: Evolutionary Dynamics and Extensive Form Games (MIT Press, 2003)

Sandholm: Population Games and Evolutionary Dynamics (MIT Press, 2011)

Szabó and Fáth: Evolutionary games on graphs, *Phys. Rep.* **446** (2007) 97-216.

Szabó and Borsos: Evolutionary potential games on lattices, *Phys. Rep.* **462** (2016) 1-60.

Wikipedia, etc.

What is game theory about?

”Game theory deals with multiplayer decision situations in which the players aim to maximize their winnnings.”

”Game theory provides the tools that allow us to predict outcomes in settings of strategic interaction.”

”[G]ames contain many of the ingredients common to all conflicts...”

”[G]ame theory is a universal language for the unification of the behavioral sciences.”

”The aim of game theory is to understand the nature and the consequences of interactions and to find an explanation for the phenomena and the evolutionary development of the living world.”

”Understand the world. Respond to the world. Change the world.”

A selective history

….			wars, games, puzzles, etc.
1944	J. von Neumann and	foundation of game theory	mathematics
	O. Morgenstern	player=businessman	economy + politics
1950	M. Flood	prisoner's dilemma	first experiments
1951	J. Nash	Nash equilibrium	
1972	J. Maynard Smith	payoff=fitness	biology
1980	R. Axelrod and W. D. Hamilton	computer tournament	sociology
1992	M. A. Nowak and R. M. May	games on lattices	modeling
1994-	physicists	stochastic spatial games	statistical physics
	E. Fehr, …	human experiment	behavioral research
2000-		evolutionary games on networks	
2004-		coevolutinary games	
		evolution of languages	linguistics
2010-		personal features	
		brain experiments	medical sciences

Topics

Introduction to game theory

basic concepts, classification, …

matrix games, Nash equilibrium, social dilemmas, ...

potential games, decomposition of matrix games

Evolutionary games

Axelrod's computer tournament, tit-for-tat strategies, …

repeated prisoner's dilemma games with stochastic reactive strategies,

repeated multi-agent games,

evolutionary games,

population dynamics, …

Spatial evolutionary games

potential games on lattices – solid state physics, spin models,

social dilemma games on lattices, phenomena supporting cooperation, …

Topics (cont.)

Evolutionary social dilemmas on networks

- additional strategies, personality, fraternal behavior, noise, …

Coevolutionary games

- several features evolve together

Animal and human experiments

- ultimatum games, trust games, …

Spatial rock-paper-scissors games (cyclic dominance)

- bacterial warfare, lizards, …
- rotating spiral patterns, …

Competing associations

- defensive associations

Basic concepts of game theory

Games = simplified real life situations of several players, each with several options that are considered quantitatively with the tools of mathematics.

Games: **players** (x,y, …), who are selfish and intelligent (rational) – homo economicus

each player wishes to maximize their own (quantified) payoff

they know the **rules, options, payoffs**, and calculus

they assume the opponents to be intelligent, too

'I know that you know that I know …'

many different rules exist

Decisions: may be simultaneous (matching pennies, rock-paper-scissors, etc.)

alternating (chess, go, etc.)

Normal-form of games: finite number of players and strategies

payoffs are tabulated (many parameters)

Two-person games: zero-sum games (U_x=–U_y) (minimax theorem: Neumann)

non-zero-sum game (U_x+U_y ≠0) (e.g., prisoner's dilemma)

Multi-player games (e.g., public goods game) can be built up from pair interactions

Games can be: non-cooperative (simultaneous decision)

cooperative (coalitions permitted)

can involve: incomplete information

uncertainties, errors in decision-making

…

The goal of game theory and evolutionary game theory:

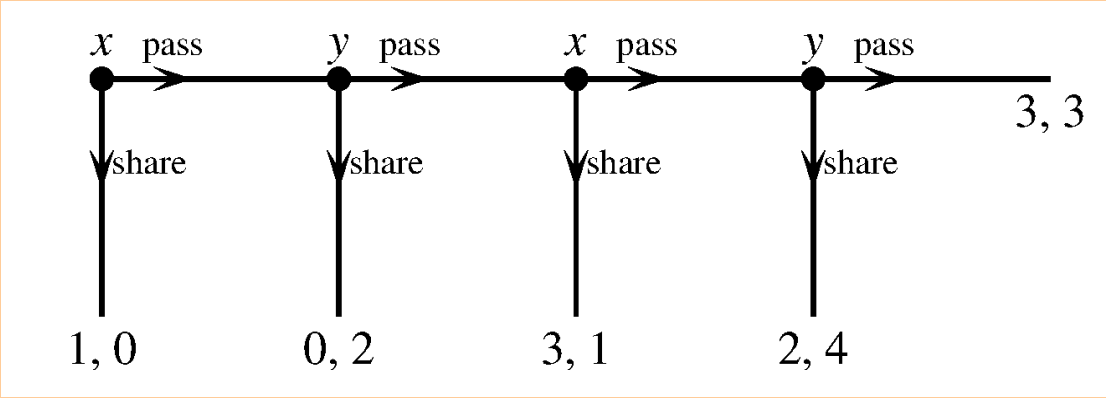
- to recommend strategies to the players,
- to explore the possibilities, types of interactions, laws of nature, …
- to recommend modifications to games in order to achieve higher social income and avoid social dilemmas
- to explain phenomena, mechanisms, evolutionary processes in biology, society, languages, genes, and memes
- to draw parallels between different fields of science
- to initiate the utilization of results (particularly in economy, policy, and education)

Centipede game (Rosenthal 1981)

Two players (*x* and *y*) choose alternately between two options:

- to end the game and share the pot (with some self-preference)
- to pass the slowly increasing pot to the other player (the game is continued)

The original version had a limit of 100 rounds (hence the name)



number pairs indicate the payoffs of player *x* and *y*

Rational solution: choose 'share' in the first step, because (backward induction)

- in the last step player *y* should choose 'share' as it provides her a higher payoff
- the unsatisfied player *x* can prevent her loss by choosing 'share' in the previous step
- the unsatisfied player *y* can in turn prevent her own loss by choosing 'share' in the previous step, etc.
- finally we get the suggested solution (via the elimination of dominated strategies that takes into account the effect of the 'shadow of the future')
- Notice: players would receive higher payoffs at the last step (it is a social dilemma)

Real-life situations: governmental privatization, killing the goose that lays golden eggs, …