

CREST - GENES

Cours doctoraux 2023 – 2024

EVOLUTIONARY GAME THEORY

Jörgen Weibull

Stockholm School of Economics

December 7-18, 2023.

SCHEDULE	Mondays	11:th December 2023 18:th December 2023	From 09:15 to 12:00	TBA
	Thursdays	7th December 2023 14th December 2023	From 09:15 to 12:00	TBA

Aims and objectives

The aim of this course is to introduce participants to concepts and results in evolutionary game theory of relevance for economics.

Evolutionary game theory was pioneered by John Maynard Smith and George Price in an article in Nature in 1973. Inspired by non-cooperative game theory, they suggested a solution concept for evolutionary biology, namely, evolutionary stability of strategies. That approach, which generalizes Darwin's natural selection paradigm from "perfect competition" to "imperfect competition" in the survival of the fittest, has spurred a large literature not only in biology but also in many behavioral and social sciences including economics.

In his 1950 Ph.D. thesis (in mathematics at Princeton university), John Nash proposed two interpretations of his equilibrium concept, one rationalistic (or epistemic) and one population-statistical (or evolutionary). Instead of imagining that the interaction in question takes place exactly once under common knowledge between perfectly rational individuals, as in the rationalistic interpretation, the population-statistical interpretation is that the interaction takes place recurrently in random matchings between boundedly rational individuals from large populations, one population for each player role in the game. This interpretation is very close to that made in evolutionary game theory, and it turns out that it has behavioral implications for Nash equilibrium and beyond.

This course will introduce the participants to such concepts as evolutionary and neutral stability of strategies, the single-population replicator dynamic, deterministic and stochastic multi-population dynamics, and approaches to preference evolution, that is, models in which individuals act rationally given their preferences, but preferences evolve in the population according to how well individuals with those preferences do in the interactions at hand. Key results in this broad literature will be presented and discussed, in particular, their implications for rational behavior and for point- and set-valued solution concepts in non-cooperative game theory. Time allowing, we will also briefly discuss pre-play communication, language, social conventions and norms.

Course outline

1. Introduction (3hrs).
 - History of thought in economics and evolutionary biology
 - The notions of evolutionary stability of (pure or mixed) strategies in symmetric games
 - Relations to Nash equilibrium, proper equilibrium, and backward induction in games
 - The single-population replicator dynamic in symmetric games, and relations to evolutionary stability
2. Multi-population dynamics (4hrs).
 - The Taylor multi-population replicator dynamics in arbitrary finite games
 - Generalized multi-population dynamics
 - Implications for dominated strategies, rationalizability, Nash equilibrium and beyond
 - Stochastic multi-population dynamic processes: a law of large numbers, exit times and visitation rates, relations to the deterministic mean-field equations
 - Preliminary experimental results: "Game lab"
3. Preference evolution (4hrs).
 - History of thought
 - Evolutionarily stable preferences under complete information: "The strength of family ties"
 - Evolutionarily stable preferences under incomplete information: "Homo moralis"
 - Stochastic population genetics: "Genes, guns, and culture"
 - Experimental evidence: "the Zürich experiment"
 - Implications for economic theory and economic policy
4. Extensions and avenues for further research (1hrs)
 - Theory
 - Experiments
 - Policy

Pre-requisites

Knowledge of microeconomic theory, non-cooperative game theory and mathematics at the level of advanced master courses, or first-year Ph.D. courses, in economics.

Literature

The lectures will focus on a small selection from the reference given below. The main text for the first part of the course is my MIT Press book *Evolutionary Game Theory* (reference item 56). Participants are recommended to familiarize themselves in advance with themes and approaches in evolutionary game theory, for example by reading abstracts and introductions to a few articles that seem interesting, by looking up sources and discussions on the internet, and by buying or borrowing one or two of the books.

1. Alger, I., and J. Weibull (2010): "Kinship, incentives and evolution", *American Economic Review* 100, 1725-1758.
2. Alger, I., and J. Weibull (2013): "Homo moralis---preference evolution under incomplete information and assortative matching", *Econometrica* 81, 2269-2302.
3. Alger, I., and J. Weibull (2016): "Evolution and Kantian morality", *Games and Economic Behavior* 98: 56-67.
4. Alger, I., J. Weibull and L. Lehmann (2020): "The evolution of preferences in structured populations: genes, guns, and culture", *Journal of Economic Theory* 185.
5. Axelrod, R. (1984): *The Evolution of Cooperation*. New York: Basic Books.

6. Becker, G. (1976): "Altruism, egoism, and genetic fitness: economics and sociobiology", *J. Econ. Lit.* 14:817–26.
7. Benaïm, M. and J. Weibull: "Deterministic approximation of stochastic evolution in games", *Econometrica* 71: 873-903.
8. Bergstrom, T. (1995): "On the Evolution of Altruistic Ethical Rules for Siblings." *American Economic Review*, 85: 58–81.
9. Bisin, A., and T. Verdier (2001): "The Economics of Cultural Transmission and the Dynamics of Preferences." *Journal of Economic Theory* 97: 298–319.
10. Bowles, S. (2009): "Did Warfare Among Ancestral Hunter-Gatherers Affect the Evolution of Human Social Behaviors?" *Science* 324: 1293–8.
11. Camerer, C. (2003): *Behavioral Game Theory*. Russell Sage.
12. Dekel, E., J. Ely, and O. Yilankaya. 2007. "Evolution of Preferences", *Review of Economic Studies* 74 (3): 685–704.
13. Demichelis, S., and J. Weibull (2008): "Language, meaning, and games: A model of communication, coordination, and equilibrium", *American Economic Review* 98, 1292–1311.
14. Demichelis, S., and K. Ritzberger (2003): "From evolutionary to strategic stability," *Journal of Economic Theory* 113, 51-75.
15. Frank, R. (1987): "If Homo economicus could choose his own utility function, would he want one with a conscience?" , *American Economic Review* 77: 593–604.
16. Friedman, M. (1953): *Essays in Positive Economics*. Univ. Chicago Press.
17. Güth, W., and B. Peleg (2001): "When Will Payoff Maximization Survive? An Indirect Evolutionary Analysis", *Journal of Evolutionary Economics*, 11: 479–99.
18. Hamilton, W. (1964): "The Genetical Evolution of Social Behaviour. I+II." *Journal of Theoretical Biology* 7: 1–16 and 17-52.
19. Heifetz A. and E. Segev (2004): "The evolutionary role of toughness in bargaining", *Games and Economic Behavior* 49: 117–34.
20. Heifetz A., C. Shannon, and Y. Spiegel (2007a): "The dynamic evolution of preferences", *Economic Theory* 32:251–86.
21. Heifetz A., C. Shannon, and Y. Spiegel (2007b): "What to maximize if you must", *Journal of Economic Theory* 133: 31–57.
22. Hirshleifer J. (1977): "Economics from a biological viewpoint", *Journal of Law and Economics* 20: 1–52.
23. Hofbauer, J. and K. Sigmund (1988): *The Theory of Evolution and Dynamical Systems*. London Mathematical Society Student Texts 7.
24. Hofbauer, J. and K. Sigmund (1998): *Evolutionary Games and Population Dynamics*. Cambridge University Press.
25. Hofbauer, J. and J. Weibull (1996): "Evolutionary selection against dominated strategies", *Journal of Economic Theory* 71: 558-573.
26. Kohlberg, E. and J.-F. Mertens (1986): "On the strategic stability of equilibria," *Econometrica* 54, 1003-1037.
27. Kandori, M. (1997): "Evolutionary Game Theory in Economics", in Kreps, D. M. and K. F. Wallis (eds.), *Advances in Economics and Econometrics: Theory and Applications*, Vol. I, Cambridge University Press.
28. Kreps, D. M., and R. Wilson (1982): "Sequential equilibrium," *Econometrica* 50, 863-894.
29. Lewis, D. (1969): *Convention: A Philosophical Study*. Harvard University Press.
30. Lindbeck, A., and S. Nyberg (2006): "Raising Children to Work Hard: Altruism, Work Norms, and Social Insurance", *Quarterly Journal of Economics* 121: 1473–503.
31. Maynard Smith, J. (1982): *Evolution and the Theory of Games*. Cambridge University Press.
32. Maynard Smith, J. and G. Price (1973): "The logic of animal conflict", *Nature* 246.
33. Myerson, R., and J. Weibull (2015): "Tenable strategy blocks and settled equilibria," *Econometrica* 83, 943-976.

34. Nash, J.F. (1950): *Non-Cooperative Games*, Ph.D. thesis, Princeton University.
35. Newton, J. (2018): "Evolutionary game theory: a renaissance", *Games* 9, 1-67.
36. Ritzberger, K. and J. W. Weibull (1995): "Evolutionary selection in normal-form games," *Econometrica* 63, 1371-1399.
37. Robson, A. (1990): "Efficiency in evolutionary games: Darwin, Nash and the secret handshake", *Journal of Theoretical Biology* 144: 379-396.
38. Samuelson, L. (1992): "Dominated strategies and common knowledge," *Games and Economic Behavior* 4, 284-313.
39. Samuelson, L. (1997): *Evolutionary Games and Equilibrium Selection*. MIT Press.
40. Samuelson, L., and J. Zhang (1992): "Evolutionary stability in asymmetric games", *Journal of Economic Theory* 57: 363_391
41. Sandholm, W. (2010): *Population Games and Evolutionary Dynamics*. MIT Press.
42. Schelling, T. (1960): *The Strategy of Conflict*. Harvard University Press.
43. Swinkels, J. (1992): "Evolutionary stability with equilibrium entrants," *Journal of Economic Theory* 57, 306-332.
44. Taylor, P. (1979): "Evolutionary stable strategies with two types of player," *Journal of Applied Probability* 16, 76-83.
45. Taylor, P., and L. Jonker (1978): "Evolutionary Stable Strategies and Game Dynamics," *Mathematical Biosciences*, 40, 145–156.
46. Thompson, F. B. (1952): "Equivalence of Games in Extensive Form," RAND Research Memorandum No. 759.
47. van Damme, E. (1984): "A relation between perfect equilibria in extensive-form games and proper equilibria in normal-form games," *International Journal of Game Theory* 13, 1-13.
48. van Damme, E. (1987): *Stability and Perfection of Nash Equilibria*. Springer Verlag.
49. Weibull, J. (1995): *Evolutionary Game Theory*. MIT Press.
50. Young, P. (1993): "An evolutionary model of bargaining", *Journal of Economic Theory* 59: 145-168.