PURDUE
KRANNERT
SCHOOL OF MANAGEMENT

Econ 690: Agent-based Computational Economics

Spring 2017 (Mod 4)

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Office Hours:	TR 2-3pm and by appointment
Office:	KRAN 410
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Class Time:	TR 4.30-6 PM
Class Room:	RAWL 3070

Overview

- Agent-based Computational Economics (*ACE*) is the computational study of economic systems involving interacting agents who do not necessarily possess perfect rationality and information. In addition to equilibrium analysis, agent-based models focus on out-of-equilibrium dynamics that may or may not lead to equilibrium in the long run. The two main goals of this course are: i) to provide a foundation for implementing agent-based simulations in Python; and ii) to use agent-based approach to explain and/or complement findings from studies that use human subject experiments.

- The course will have two parts: The first part will provide numerical and simulation tools that are necessary to conduct agent-based simulation experiments. The second part will be devoted to applications of these tools in a variety of problems in experimental and computational economics such as the study of learning, repeated games, and market design.

Recommended Texts:

Tesfatsion, Leigh, and Kenneth L. Judd, eds. *Handbook of computational economics: agent-based computational economics*. Vol. 2. Elsevier, 2006.

Course Materials:

Slides from class and other relevant information will be posted on blackboard.

Course Requirements:

1. **Written responses to the readings (12%) [Starting the second week of class]:**
By 9pm on the night before class, everyone must submit a brief question or comment about the readings via blackboard. Credit will be based on evidence that you have done the readings carefully. Acceptable responses include (but are not limited to):

- Insightful questions and critiques
- Clarification questions about ambiguities
- Possible extensions or related studies
- Thoughts on the paper's importance
- Summaries of the most important things you have learned

2. Class participation (8%):
Students are expected to be present and participate actively in the discussions.

3. Oral presentations/discussion moderation (20%):
Each student will be expected to lead two discussions on the readings. The discussion can begin with a brief summary/overview of the important points in the readings, but the assumption is to be that everyone has already completed the readings. The student may either present material related to the readings (perhaps from an outside source) or moderate a class discussion about the readings. In the latter case, the student must be prepared to keep the conversation flowing.

4. HW - programming/simulation/replication exercises (5) (25%):
Each student will be required to complete five weekly programming assignments of his/her own choosing. It is recommended that at least one exercise will be completed in conjunction with the student's oral presentation/discussion/moderation.

Grading criteria for programming assignments:

- 3 – Code submitted, but does not run.
- 3.5 – Code runs, but results are incomplete.
- 4 – Code runs, results are complete but some results are incorrect.
- 4.5 – Good analysis, all results are well presented
- 5 – Excellent, with interesting research issues identified. Doing more than what has been asked.

5. Final project (35%):
A more extensive final project, along with written report, will be due on the last day of class. Students will be expected to agree with the instructor on the topic of the project by about halfway through the module. Please submit a copy of your code, your final report, and any relevant data by May 2nd.

Summary

Final Project	35%
5 Exercises	25%
Class Participation	8%
Written Response to the Readings	12%
Presentation	20%

[Tentative] Schedule:

Week	**Class Contents**	**Readings**	**Due on Tue**
Week 1	Overview of Agent-based Computational Economics. Introduction to Python. Monte Carlo Simulations.	1	HW0
	---------- Spring Vacation ----------		
Week 2	Markets	2	HW1
Week 3	Learning	3	HW2
Week 4	Repeated Games	4	HW3
Week 5	Networks	5	HW4
Week 6	Computing Equilibria	6	HW5
Week 7	Various Topics	7	
Finals Week	**Final Project Due (No Later Than 11.59pm on May 2nd)**		

[Tentative] Reading List

Week 1. Introduction

Agent-based Computational Economics Introduction

- Thomas Schelling. Some Fun, Thirty-Five Years Ago. *Handbook of Computational Economics* 2 (2006): 1639–1644. **Chapter 37.**
- Leigh Tesfatsion and Kenneth Judd. **Preface** to *Handbook of Computational Economics 2(2006).*
- Tesfatsion, Leigh. "Agent-Based Computational Economics: A Constructive Approach to Economic Theory." *Handbook of Computational Economics* 2 (2006): 831–80. **Chapter 16.**
- Judd, Kenneth. "Computationally Intensive Analyses in Economics." *Handbook of Computational Economics* 2 (2006): 881–94. **Chapter 17.**

Experimental-Computational Complementarities

- Duffy, John. "Agent-Based Models and Human Subject Experiments." Handbook of Computational Economics 2 (2006): 949–1011. **Chapters 19.1**
- Contini, Bruno, Roberto Leombruni, and Matteo Richiardi. "Exploring a New ExpAce: The Complementarities between Experimental Economics and Agent based Computational Economics." *Journal of Social Complexity* 3, no. 1 (2006). http://laboratoriorevelli.it/_pdf/wp45.pdf.

Introduction to Python

- Main Website: https://www.python.org/
- Beginner's Guide: https://wiki.python.org/moin/BeginnersGuide
- Download: Anaconda (free Python distribution that includes many packages, and IDEs)

Monte Carlo Simulations

- Judd, Kenneth L. Numerical Methods in Economics. MIT Press, 1998. Chapter 8: Monte Carlo and Simulation Methods

Week 2. Markets

Zero Intelligence Agents

- Duffy, John. "Agent-Based Models and Human Subject Experiments." Handbook of Computational Economics 2 (2006): 949–1011. **Chapters 19.2**
- Gode, Dhananjay K., and Shyam Sunder. "Allocative Efficiency of Markets with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Rationality." *Journal of Political Economy*, 1993, 119–37.

- Gode, Dhananjay K., and Shyam Sunder. "What Makes Markets Allocationally Efficient?" *The Quarterly Journal of Economics*, 1997, 603–30.

Evolutionary Algorithms

- Jasmina Arifovic (1994). "Genetic Algorithm Learning and the Cobweb Model." *Journal of Economic Dynamics and Control*, Special Issue on Computer Science and Economics, 18, no. 1 (January 1994): 3–28. doi:10.1016/0165-1889(94)90067-1.
- Duffy, John. "Agent-Based Models and Human Subject Experiments." Handbook of Computational Economics 2 (2006): 949–1011. **Chapter 19.4**

More on Zero-Intelligence Agents and Market Design

Farmer, J. Doyne, Paolo Patelli, and Ilija I. Zovko. "The Predictive Power of Zero Intelligence in Financial Markets." *Proceedings of the National Academy of Sciences of the United States of America* 102, no. 6 (February 8, 2005): 2254–59. doi:10.1073/pnas.0409157102.

Week 3. Learning

Reinforcement Learning in Economics

- Brenner, Thomas. "Agent Learning Representation: Advice on Modelling Economic Learning." Handbook of Computational Economics 2 (2006): 895-947. **Chapter 18**
- Duffy, John. "Agent-Based Models and Human Subject Experiments." Handbook of Computational Economics 2 (2006): 949–1011. **Chapter 19.3**

Reinforcement Learning in Computer Science

- Sutton, Richard S., and Andrew G. Barto. Reinforcement Learning: An Introduction. The MIT Press, 1998. Chapter 3-6.
- Waltman, L. and K. Uzay. Q-learnining agents in a Cournot oligopoly model. *Journal of Economic Dynamics & Control* 32 (2008): 3275-3293

Evolutionary Algorithms

- Marimon, Ramon, Ellen McGrattan, and Thomas J. Sargent. "Money as a Medium of Exchange in an Economy with Artificially Intelligent Agents." *Journal of Economic Dynamics and Control* 14, no. 2 (1990): 329–73.

More Experiments on Learning

Arifovic, Jasmina, Richard D. McKelvey, and Svetlana Pevnitskaya. "An Initial Implementation of the Turing Tournament to Learning in Repeated Two-Person Games." *Games and Economic Behavior* 57, no. 1 (2006): 93–122.

Arifovic, Jasmina, and John Ledyard. "Scaling up Learning Models in Public Good Games." *Journal of Public Economic Theory* 6, no. 2 (2004): 203–38.

Duffy, J., and N. Feltovich. "Does Observation of Others Affect Learning in Strategic Environments? An Experimental Study." *International Journal of Game Theory* 28, no. 1 (1999): 131–52.

Erev, Ido, and Alvin E. Roth. "Predicting How People Play Games: Reinforcement Learning in Experimental Games with Unique, Mixed Strategy Equilibria." *American Economic Review*, 1998, 848–81.

Feltovich, Nick. "Reinforcement-Based vs. Belief-Based Learning Models in Experimental Asymmetric-Information Games." *Econometrica* 68, no. 3 (May 1, 2000): 605–41.

Week 4. Repeated Games

Repeated Prisoner's Dilemma

- Axelrod, Robert. "Agent-based Modeling as a Bridge Between Disciplines." Handbook of Computational Economics 2 (2006): 1565–1584. **Chapter 33.**
- Axelrod, Robert. "The Evolution of Strategies in the Iterated Prisoner's Dilemma." The Dynamics of Norms, 1987, 1–16.
- Miller, John H. "The Coevolution of Automata in the Repeated Prisoner's Dilemma." *Journal of Economic Behavior & Organization* 29, no. 1 (1996): 87–112.
- Ioannou, Christos A., and Julian Romero. "A Generalized Approach to Belief Learning in Repeated Games." *Games and Economic Behavior* 87 (September 2014): 178–203.
- Romero, J. and Y. Rosokha. "The Evolution of Cooperation: The Role of Costly Strategy Adjustments." https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2805689
- Dal Bó, Pedro, and Guillaume R. Fréchette. "The evolution of cooperation in infinitely repeated games: Experimental evidence." *The American Economic Review* 101.1 (2011): 411-429.
- Fudenberg, Drew, David G. Rand, and Anna Dreber. "Slow to anger and fast to forgive: Cooperation in an uncertain world." *The American Economic Review* 102.2 (2012): 720-749.
- Embrey, M., Frechette, G., and S. Yuksel. "Cooperation in the Finitely Repeated Prisoner's Dilemma." Working Paper.

More (Computational) Experiments on Repeated Games

Lindgren, K. (1992). "Evolutionary phenomena in simple dynamics". In: Langton, C.G., Taylor, C., Farmer, J.D., Rasmussen, S. (Eds.), Artificial Life II. Addison-Wesley, Reading, MA, pp. 295–312.

Week 5. Networks

- Wilhite, Allen. "Economic Activity on Fixed Networks." Handbook of Computational Economics 2 (2006): 1013-1045. **Chapter 20.**
- Kearns, Michael, Siddharth Suri, and Nick Montfort. "An Experimental Study of the Coloring Problem on Human Subject Networks." *Science* 313, no. 5788 (2006): 824–27.
- Kirchkamp, Oliver, and Rosemarie Nagel. "Naive Learning and Cooperation in Network Experiments." Games and Economic Behavior 58, no. 2 (February 2007): 269–92. doi:10.1016/j.geb.2006.04.002.

More (Computational) Experiments on Networks

Corbae, Dean, and John Duffy. "Experiments with Network Formation." *Games and Economic Behavior* 64, no. 1 (September 2008): 81–120.

Goeree, Jacob K., Arno Riedl, and Aljaz Ule. "In Search of Stars: Network Formation among Heterogeneous Agents." *Games and Economic Behavior* 67, no. 2 (November 2009): 445–66.

Kirchkamp, O. (2000). "Spatial evolution of automata in the prisoners' dilemma". Journal of Economic Behavior and Organization 43, 239–262.

Tesfatsion, Leigh. *A Trade Network Game with Endogenous Partner Selection*. Springer, 1997.

Watts, Duncan J., and Steven H. Strogatz. "Collective Dynamics of 'small-World' Networks." *Nature* 393, no. 6684 (June 4, 1998): 440–42.

Week 6. Computing Equilibria

- Judd, Kenneth L. Numerical Methods in Economics. MIT Press, 1998. Chapter 4.9: Computing Nash Equilibria;
- McKelvey, Richard D., and Thomas R. Palfrey. "Quantal Response Equilibria for Normal Form Games." *Games and Economic Behavior* 10, no. 1 (1995): 6–38.
- Huggett, Mark. "The Risk-Free Rate in Heterogeneous-Agent Incomplete-Insurance Economies." *Journal of Economic Dynamics and Control* 17, no. 5–6 (September 1993).

More on QRE

Goeree, Jacob K, Thomas R Palfrey, Brian W Rogers, and Richard D McKelvey. "Self-Correcting Information Cascades." *Review of Economic Studies* 74, no. 3 (July 1, 2007): 733–62. doi:10.1111/j.1467-937X.2007.00438.x.

McKelvey, Richard D., and Thomas R. Palfrey. "Quantal response equilibria for extensive form games." *Experimental economics* 1.1 (1998): 9-41.

Turocy, Theodore L. "A dynamic homotopy interpretation of the logistic quantal response equilibrium correspondence." *Games and Economic Behavior* 51.2 (2005): 243-263.

Turocy, Theodore L. "Computing sequential equilibria using agent quantal response equilibria." *Economic Theory* 42.1 (2010): 255-269.

Week 7. Dynamic Optimization

- Judd, Kenneth L. *Numerical Methods in Economics*. MIT Press, 1998. Chapter 12: Numerical Dynamic Programming.
- Noussair, C.N. and K.J. Matheny (2000), "An Experimental Study of Decisions in Dynamic Optimization Problems," *Economic Theory* 15, 389-419.

More experiments on dynamic optimization

Ballinger, T. Parker, Michael G. Palumbo, and Nathaniel T. Wilcox. "Precautionary Saving and Social Learning across Generations: An Experiment*." *The Economic Journal* 113, no. 490 (2003): 920–47.

Brown, Alexander L., Zhikang Eric Chua, and Colin F. Camerer. "Learning and Visceral Temptation in Dynamic Saving Experiments." *The Quarterly Journal of Economics* 124, no. 1 (February 1, 2009): 197–231. doi:10.1162/qjec.2009.124.1.197.

Ballinger, T. Parker, Eric Hudson, Leonie Karkoviata, and Nathaniel T. Wilcox. "Saving Behavior and Cognitive Abilities." *Experimental Economics* 14, no. 3 (2011): 349–74.