PURDUE
KRANNERT
SCHOOL OF MANAGEMENT

ECON 690: Computational Economics

Spring 2015

Professor:	Yaroslav Rosokha
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Office Hours:	MW 4.30-5.30 PM, and by appointment
Office:	Krannert 410
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Class Time:	8-9.30 AM
Class Room:	RAWLS 2077

Overview

- The two main goals of this course are: 1) to provide numerical solution methods, optimization techniques, and simulation methods and implement them using R, Python, Mathematica and/or MATLAB; and 2) to apply these tools to the domain of experimental and computational economics.
- The course will have two parts: the first part will provide methods for solving optimization problems, and numerical and simulation tools that are necessary to conduct simulation experiments.
- The second part of the course is devoted to applications of these tools in a variety of problems in experimental and computational economics such as the study of individual choice, learning, repeated games, and market design.

Recommended Texts:

Adda, Jerome, and Russell W. Cooper. *Dynamic Economics: Quantitative Methods and Applications*. Cambridge, Mass: The MIT Press, 2003.

Sutton, Richard S., and Andrew G. Barto. *Reinforcement Learning: An Introduction*. The MIT Press, 1998. [Available Online: http://webdocs.cs.ualberta.ca/~sutton/book/the-book.html]

Course Materials:

Slides from class will be posted on blackboard. Other relevant links and information will be posted on the course resources page: http://web.ics.purdue.edu/~yrosokha/comp_econ_2015.html

Course Requirements:

1. Written responses to the readings (15%) [Starting the second week of class]:

By 9pm on the night before a class with a new reading assignment due, everyone must submit a brief question or comment about the readings via email. Please use the subject line "Econ690 readings for [due date]". In some cases, specific questions may be posted along with the readings. But in general, it is free form. 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
- Solutions to problems or exercises posed in the readings
- Thoughts on what you would like to learn about in more detail
- Possible extensions or related studies
- Thoughts on the paper's importance
- Summaries of the most important things you learned

2. Class participation (15%):
Students are expected to be present and participate actively in the discussions.

3. Oral presentation/discussion moderation (10%):
Each student will be expected to lead a discussion on one of 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. If you would like feedback on your discussion topic, please contact Yaroslav (yrosokha@purdue.edu) by 9pm two nights before the discussion.

4. Preliminary programming/simulation exercises (5) (20%):
Each student will be required to complete five weekly programming assignments of his/her own choosing. In most cases these will come from the exercises, though other options are possible upon consultation with the instructor. Please use the subject line "Econ690 HW[#]". It is recommended that one exercise will be completed in conjunction with the student's oral presentation/discussion/moderation.

Grading criteria for programming assignments:

- 8 - Good job, but there is room for improvement
- 9 - Good analysis, results well presented
- 10 - Excellent, with interesting research issues identified. Doing more than what has been asked.

5. Final project (40%):
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 email a copy of your code, your final report, and any relevant data by May 5th.

Summary

Final Project	40%
5 Exercises	20%
Class Participation	15%
Written Response to the Readings	15%
Presentation	10%

Tentative Schedule:

Date	Class Contents	Readings	Due
3/9	1 Introduction. Solution Methods: Dynamic Programming, Monte Carlo Simulations, Temporal Difference Methods	1	
3/11	2 Solution Methods Continued. Programming.	1	
3/16	---------- Spring Vacation ----------		
3/18			
3/23	3 Numerical Methods: Function Approximation, Gradient Descent, Genetic Algorithm, Simulated Annealing	2	HW1
3/25	4 Numerical Methods Continued.	2	
3/30	5 Solution Methods Continued: Solving for Equilibrium, Distributions	3	HW2
4/1	6 Solution Methods Continued; Quantal Response Equilibrium	3	
4/6	7 Simulation Assisted Estimation and Testing	4	HW3
4/8	8 Simulation Assisted Experimental Design	5	
4/13	9 Application: Choice Under Risk and Uncertainty	6	HW4
4/15	10 Application: Agent-based Computational Economics	7	
4/20	11 Application: Markets and Auctions	8	HW5
4/22	12 Application: Repeated Games	9	
4/27	13 Application: Learning	10	
4/29	14 Application: Networks	11	
5/5	**Final Project Due No Later Than Tuesday, May 5**		

Reading List [Tentative]

1) Solution Methods: Dynamic Programming (DP), Monte Carlo (MC), and Temporal-Difference (TD)

Adda, Jerome, and Russell W. Cooper. *Dynamic Economics: Quantitative Methods and Applications*. Cambridge, Mass: The MIT Press, 2003. Chapters 1 – 3.3.

Sutton, Richard S., and Andrew G. Barto. *Reinforcement Learning: An Introduction*. The MIT Press, 1998. Chapter 3-6.

Free Programming Resources:

- R
  - http://www.r-project.org/
  - http://www.rstudio.com/
  - An Introduction to R:
    - http://cran.r-project.org/doc/manuals/r-release/R-intro.html
    - https://www.datacamp.com/courses/introduction-to-r
- Python
  - https://www.python.org/
  - http://continuum.io/downloads
  - Beginner's Guide to Python:
    - https://wiki.python.org/moin/BeginnersGuide

Experiments:

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 solving dynamic optimization problem.

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.

In depth:

Judd, Kenneth L. *Numerical Methods in Economics*. MIT Press, 1998. Chapter 12: Numerical Dynamic Programming

2) Numerical Methods

Adda, Jerome, and Russell W. Cooper. *Dynamic Economics: Quantitative Methods and Applications*. Cambridge, Mass: The MIT Press, 2003. Chapter 3: Numerical Analysis.

Sutton, Richard S., and Andrew G. Barto. *Reinforcement Learning: An Introduction*. The MIT Press, 1998. Chapter 8: Generalization and Function Approximation.

Discussion:

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.

In depth:

Judd, Kenneth L. *Numerical Methods in Economics*. MIT Press, 1998. Chapter 4-4.4: Optimization; Chapter 6: Approximation Methods; Chapter 7: Numerical Integration and Differentiation; Chapter 8: Monte Carlo and Simulation Methods

3) Solution Methods Continued

Judd, Kenneth L. *Numerical Methods in Economics*. MIT Press, 1998. Chapter 4.9: Computing Nash Equilibria;

Sutton, Richard S., and Andrew G. Barto. *Reinforcement Learning: An Introduction*. The MIT Press, 1998. Chapter 8: Generalization and Function Approximation.

Discussion:

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).

4) Simulation Assisted Estimation and Testing

Adda, Jerome, and Russell W. Cooper. *Dynamic Economics: Quantitative Methods and Applications*. Cambridge, Mass: The MIT Press, 2003. Chapter 4: Econometrics

In depth:

Train, Kenneth E. *Discrete Choice Methods with Simulation*. Cambridge university press, 2009. Chapter 10: Simulation Assisted Estimation.

Zeileis, Achim, Mark A. van de Wiel, Kurt Hornik, and Torsten Hothorn. "Implementing a Class of Permutation Tests: The Coin Package." *Journal of Statistical Software* 28, no. 8 (November 2008): 1–23.

Anderson, Marti, and Cajo Ter Braak. "Permutation Tests for Multi-Factorial Analysis of Variance." *Journal of Statistical Computation and Simulation* 73, no. 2 (2003): 85–113.

5) Using Simulations for Experimental Design

Roth, Alvin E. "The Economist as Engineer: Game Theory, Experimentation, and Computation as Tools for Design Economics." *Econometrica* 70, no. 4 (July 1, 2002): 1341–78

Sterman, John D. "Testing Behavioral Simulation Models by Direct Experiment." *Management Science* 33, no. 12 (December 1, 1987): 1572–92.

More on Experimental Design for Computer Simulations

Hunter, J. S., and T. H. Naylor. "Experimental Designs for Computer Simulation Experiments." *Management Science* 16, no. 7 (March 1, 1970): 422–34.

Kleijnen, Jack PC. "Experimental Design for Sensitivity Analysis, Optimization, and Validation of Simulation Models." *Handbook of Simulation*, 1998, 173–223.

6) Choice Under Risk and Uncertainty

Wilcox, Nathaniel T. "Stochastic Models for Binary Discrete Choice under Risk: A Critical Primer and Econometric Comparison." *Research in Experimental Economics* 12 (2008): 197–292.

Discussion

Kremer, Mirko, Stefan Minner, and Luk N. Van Wassenhove. "Do Random Errors Explain Newsvendor Behavior?" *Manufacturing & Service Operations Management* 12, no. 4 (April 9, 2010): 673–81. doi:10.1287/msom.1100.0294.

More Experiments with Stochastic Discrete Choice Model Component

Wilcox, N.T. "Stochastically More Risk averse: A Contextual Theory of Stochastic Discrete Choice under Risk." *Journal of Econometrics* 162, no. 1 (2011): 89–104.

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.

7) Agent Based Computational Economics

Duffy, John. "Agent-Based Models and Human Subject Experiments." *Handbook of Computational Economics* 2 (2006): 949–1011.

Tesfatsion, Leigh. "Agent-Based Computational Economics: A Constructive Approach to Economic Theory." *Handbook of Computational Economics* 2 (2006): 831–80.

Discussion

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 on Experimental-Computational Complementarities

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.

8) Markets and Auctions

Duffy, John. "Agent-Based Models and Human Subject Experiments." *Handbook of Computational Economics* 2 (2006): 949–1011.

Discussion:

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.

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.

Walia, Vibhu, Andrew Byde, and Dave Cliff. "Evolving Market Design in Zero-Intelligence Trader Markets." In *E-Commerce, 2003. CEC 2003. IEEE International Conference on*, 157–64. IEEE, 2003.

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

9) Repeated Games

Axelrod, Robert. "The Evolution of Strategies in the Iterated Prisoner's Dilemma." *The Dynamics of Norms*, 1987, 1–16.

Discussion:

Miller, John H. "The Coevolution of Automata in the Repeated Prisoner's Dilemma." *Journal of Economic Behavior & Organization* 29, no. 1 (1996): 87–112.

Could be interesting for discussion:

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.

Ioannou, Christos A., and Julian Romero. "A Generalized Approach to Belief Learning in Repeated Games." *Games and Economic Behavior* 87 (September 2014): 178–203.

10) Learning

Sutton, Richard S., and Andrew G. Barto. *Reinforcement Learning: An Introduction*. The MIT Press, 1998. Chapter 9: Planning and Learning.

Discussion

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

More Experiments on Learning

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.

11) Networks

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

Discussion

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.

More (Computational) Experiments on Networks

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.

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.