University of Oregon
Department of Economics

ECN 607
Seminar in Computational Economics, Spring 2021

David Evans

Office: 538 PLC
Office Hours: Thursdays 12-1pm* and Fridays 9:30-10:30am and by appointment
Office Hours Zoom Link:
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Course Description: The goal of this course is to provide students with the tools necessary to approach interesting questions in macroeconomics. The first few weeks of the course will be focused on developing the tools that will form the foundation of the course. In the remaining weeks, we will explore a variety of topics at the forefront of Macroeconomics and study how computational tools are applied to these topics. By the end of the course the goal is for students to have a toolbox of computational techniques that can be applied at the forefront of macroeconomics.

Learning Goals and Outcomes:

1) Demonstrate understanding of existing numerical techniques for solving dynamic economic problems
2) Develop good programming skills
3) Demonstrate the ability to build a solution algorithm suitable for a given economic problem

Grading: Grading will consist of problem sets due every two weeks and a replication project due at the end of the course. Grades will be determined as follows:

40%	**HOMEWORK**
60%	**REPLICATION PROJECT**

Software: We'll be studying numerical techniques to approximate competitive equilibria. You can use any language you want. I recommend using the Julia programming language as it provides an easy to learn language with performance near that of C++,C, or Fortran. I've found VS Code to be a very clean interface for working with Julia. You can find instructions for it here: https://www.julia-vscode.org/docs/dev/gettingstarted/. A good introduction to Julia can be found at https://lectures.quantecon.org/jl/learning_julia.html, which provides a good introduction to applying Julia to many economic problems.

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* Preference will be given to students of my core macro course during this period.

Homework: Electronic copies of homework assignments must be by 11:59 pm on the due date. Work in groups is encouraged but each student must submit an assignment consisting of his/her own work.

Replication Project: In the 10th class I will give a list of papers. Your assignment will be to choose one of those papers (you may also suggest your own) and to replicate the main results. The replication project will be due by 11:59PM on the Monday of finals week. Submission should include

1) A short report documenting the main results of the paper and your corresponding replication.
2) The code which produces the replication

Electronic submission of projects is preferred. In addition to the replication, each student will be required to create a short (20 minute) presentation which summarizes the methodology and main results of the paper they are going to replicate.

Academic Misconduct:
The University Student Conduct Code (available at conduct.uoregon.edu) defines academic misconduct. Students are prohibited from committing or attempting to commit any act that constitutes academic misconduct. By way of example, students should not give or receive (or attempt to give or receive) unauthorized help on assignments or examinations without express permission from the instructor. Students should properly acknowledge and document all sources of information (e.g. quotations, paraphrases, ideas) and use only the sources and resources authorized by the instructor. If there is any question about whether an act constitutes academic misconduct, it is the students' obligation to clarify the question with the instructor before committing or attempting to commit the act. Additional information about a common form of academic misconduct, plagiarism, is available at https://researchguides.uoregon.edu/citing-plagiarism.

Accessible Education:
Please let me know within the first two weeks of the term if you need assistance to fully participate in the course. Participation includes access to lectures, web-based information, in-class activities, and exams. The Accessible Education Center (http://aec.uoregon.edu/) works with students to provide an instructor notification letter that outlines accommodations and adjustments to class design that will enable better access. Contact the Accessible Education Center for assistance with access or disability-related questions or concerns.

Reporting Obligations:
I am a Student Directed Employee. For information about my reporting obligations as an employee, please see Employee Reporting Obligations on the Office of Investigations and Civil Rights Compliance (OICRC) website. Students experiencing any form of prohibited discrimination or harassment, including sex or gender-based violence, may seek information and resources at safe.uoregon.edu, respect.uoregon.edu, or investigations.uoregon.edu or contact the non-confidential Title IX office/Office of Civil Rights Compliance (541-346-3123), or Dean of Students offices (541-346-3216), or call the 24-7 hotline 541-346-SAFE for help. I am also a mandatory reporter of child abuse. Please find more information at Mandatory Reporting of Child Abuse and Neglect.

Mental Health and Wellness:
Life at college can be very complicated. Students often feel overwhelmed or stressed, experience anxiety or depression, struggle with relationships, or just need help navigating challenges in their life. If you're facing such challenges, you don't need to handle them on your own--there's help and support on campus.

As your instructor if I believe you may need additional support, I will express my concerns, the reasons for them, and refer you to resources that might be helpful. It is not my intention to know the details of what might be bothering you, but simply to let you know I care and that help is available. Getting help is a courageous thing to do—for yourself and those you care about.

University Health Services help students cope with difficult emotions and life stressors. If you need general resources on coping with stress or want to talk with another student who has been in the same place as you, visit the Duck Nest (located in the EMU on the ground floor) and get help from one of the specially trained Peer Wellness Advocates. Find out more at health.uoregon.edu/ducknest.

University Counseling Services (UCS) has a team of dedicated staff members to support you with your concerns, many of whom can provide identity-based support. All clinical services are free and confidential. Find out more at counseling.uoregon.edu or by calling 541-346-3227 (anytime UCS is closed, the After-Hours Support and Crisis Line is available by calling this same number)

Basic Needs:
Any student who has difficulty affording groceries or accessing sufficient food to eat every day, or who lacks a safe and stable place to live and believes this may affect their performance in the course is urged to contact the Dean of Students Office (346-3216, 164 Oregon Hall) for support.

This UO webpage includes resources for food, housing, healthcare, childcare, transportation, technology, finances, and legal support: https://blogs.uoregon.edu/basicneeds/food/

Religious Accommodation:
The university makes reasonable accommodations, upon request, for students who are unable to attend a class for religious obligations or observance reasons, as outlined by the university discrimination policy (Section GG). To request accommodations for this course, visit the Office of the Registrar's website and complete and submit the “Student Religious Accommodation Request” form prior to the end of the second week of the term.

Inclement Weather:
It is generally expected that class will meet unless the University is officially closed for inclement weather. If it becomes necessary to cancel class while the University remains open, this will be announced on Canvas and by email. Updates on inclement weather and closure are also communicated in other ways described here: https://hr.uoregon.edu/about-hr/campus-notifications/inclement-weather/inclement-weather-immediate-updates

Academic Disruption due to Campus Emergency:
In the event of a campus emergency that disrupts academic activities, course requirements, deadlines, and grading percentages are subject to change. Information about changes in this course will be communicated as soon as possible by email, and on Canvas. If we are not able to meet face-to-face, students should immediately log onto Canvas and read any announcements and/or access alternative assignments. Students are also encouraged to continue the readings and other assignments as outlined in this syllabus or subsequent syllabi.

Outline of Course Material:

The following is a tentative schedule of lectures and may be subject to change.

Part 1: Tools (Weeks 1-5)

1. **Random Variables and Markov Processes:** Pseudo random variables, Monte-Carlo experiments, Finite state Markov Processes, The Kalman Filter
2. **Bellman Equations:** Value function iteration, Howard Improvement Algorithm, Solving Models with Uncertainty, Application: RBC model
3. **Root Solving:** 1 Dimensional Root Solving, N Dimensional Root Solving, Solving Perfect Foresight Models, The Diamond Mortensen Pissarides Matching Model
4. **Optimization:** 1 Dimensional Optimization, Multi-Dimensional Optimization: Gradient and Non-Gradient methods, Constrained Optimization, Optimal Tax Policy.
5. **Interpolation:** B-Splines, Spectral Methods, Basis Functions
6. **Numerical Integration:** Gaussian Quadrature, Smolyak quadrature, Monte Carlo Methods
7. **Perturbation Theory:** Linearization and Log Linearization, Blanchard-Kahn Conditions, Higher Order Perturbation, Pruning Methods
8. **Accuracy Measures:** Residuals in the model's equations, errors in model's variables. Economically meaningful measures of accuracy.
9. **Parallel processing:** Shared and Distributed Memory, Race Conditions, MPI
10. **Writing Efficient Code:** Application to a consumption savings problem.

Part 2: Challenging Economic Applications (Weeks 6-10)

1. **Models with A Continuum of State Variables:** Bewely/Aiyagari Models, Transitions Paths, Krusell-Smith Models, Modern Perturbation Techniques
2. **Learning in Heterogeneous Agent Models:** Locally Rational Agents
3. **Bayesian Estimation of DSGE Models:** Monte Carlo methods for DSGE models
4. **Dynamic Games:** Markov perfect equilibria, stochastic games and time inconsistency
5. **Default Risk:** An introduction to sovereign default models

References (Part 1):

Barillas, Francisco, and Jesús Fernández-Villaverde. 2007. “A Generalization of the Endogenous Grid Method.” *Journal of Economic Dynamics and Control* 31(8):2698–2712. doi: 10.1016/j.jedc.2006.08.005.

Carroll, Christopher D. 2006. “The Method of Endogenous Gridpoints for Solving Dynamic Stochastic Optimization Problems.” *Economics Letters* 91(3):312–20. doi: 10.1016/j.econlet.2005.09.013.

Fernández-Villaverde, Jesús, and Juan F. Rubio-Ramírez. 2006. “Solving DSGE Models with Perturbation Methods and a Change of Variables.” *Journal of Economic Dynamics and Control* 30(12):2509–31. doi: 10.1016/j.jedc.2005.07.009.

Fernández-Villaverde, Jesús, and David Zarruk Valencia. 2018. *A Practical Guide to Parallelization in Economics*. w24561. National Bureau of Economic Research.

Judd, Kenneth L. 1998. *Numerical Methods in Economics*. MIT Press.

Judd, Kenneth L., Lilia Maliar, and Serguei Maliar. 2017. “Lower Bounds on Approximation Errors to Numerical Solutions of Dynamic Economic Models.” *Econometrica* 85(3):991–1012. doi: https://doi.org/10.3982/ECTA12791.

Maliar, Lilia, and Serguei Maliar. 2013. “Envelope Condition Method versus Endogenous Grid Method for Solving Dynamic Programming Problems.” *Economics Letters* 120(2):262–66. doi: 10.1016/j.econlet.2013.04.031.

Miranda, Mario J., and Paul L. Fackler. 2004. *Applied Computational Economics and Finance*. MIT Press.

References (Part 2):

Arellano, Cristina. 2008. “Default Risk and Income Fluctuations in Emerging Economies.” *American Economic Review* 98(3):690–712. doi: 10.1257/aer.98.3.690.

Auclert, Adrien, Bence Bardóczy, Matthew Rognlie, and Ludwig Straub. 2019. *Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models*. w26123. National Bureau of Economic Research.

Boppart, Timo, Per Krusell, and Kurt Mitman. 2018. “Exploiting MIT Shocks in Heterogeneous-Agent Economies: The Impulse Response as a Numerical Derivative.” *Journal of Economic Dynamics and Control* 89:68–92. doi: 10.1016/j.jedc.2018.01.002.

Cao, Dan, and Iván Werning. 2018. “Saving and Dissaving With Hyperbolic Discounting.” *Econometrica* 86(3):805–57. doi: https://doi.org/10.3982/ECTA15112.

Den Haan, Wouter J., and Joris De Wind. 2012. “Nonlinear and Stable Perturbation-Based Approximations.” *Journal of Economic Dynamics and Control* 36(10):1477–97. doi: 10.1016/j.jedc.2012.05.001.

Fernández-Villaverde, J., J. F. Rubio-Ramírez, and F. Schorfheide. 2016. “Chapter 9 - Solution and Estimation Methods for DSGE Models.” Pp. 527–724 in *Handbook of Macroeconomics*. Vol. 2, edited by J. B. Taylor and H. Uhlig. Elsevier.

Judd, Kenneth L., Lilia Maliar, and Serguei Maliar. 2011. “Numerically Stable and Accurate Stochastic Simulation Approaches for Solving Dynamic Economic Models.” *Quantitative Economics* 2(2):173–210. doi: https://doi.org/10.3982/QE14.

Judd, Kenneth L., Lilia Maliar, Serguei Maliar, and Inna Tsener. 2017. “How to Solve Dynamic Stochastic Models Computing Expectations Just Once.” *Quantitative Economics* 8(3):851–93. doi: https://doi.org/10.3982/QE329.

Judd, Kenneth L., Lilia Maliar, Serguei Maliar, and Rafael Valero. 2014. “Smolyak Method for Solving Dynamic Economic Models: Lagrange Interpolation, Anisotropic Grid and Adaptive Domain.” *Journal of Economic Dynamics and Control* 44:92–123. doi: 10.1016/j.jedc.2014.03.003.

Krusell, Per, Burhanettin Kuruşçu, and Anthony A. Smith. 2002. “Equilibrium Welfare and Government Policy with Quasi-Geometric Discounting.” *Journal of Economic Theory* 105(1):42–72. doi: 10.1006/jeth.2001.2888.

Krusell, Per, and Anthony A. Smith, Jr. 2003. “Consumption-Savings Decisions with Quasi-Geometric Discounting.” *Econometrica* 71(1):365–75. doi: 10.1111/1468-0262.00400.

Maliar, Lilia, and Serguei Maliar. 2006. “The Neoclassical Growth Model with Heterogeneous Quasi-Geometric Consumers.” *Journal of Money, Credit and Banking* 38(3):635–54.

Maliar, Lilia, and Serguei Maliar. 2014. “Chapter 7 - Numerical Methods for Large-Scale Dynamic Economic Models.” Pp. 325–477 in *Handbook of Computational Economics*. Vol. 3, *Handbook of Computational Economics Vol. 3*, edited by K. Schmedders and K. L. Judd. Elsevier.

Maliar, Lilia, Serguei Maliar, and Sébastien Villemot. 2013. “Taking Perturbation to the Accuracy Frontier: A Hybrid of Local and Global Solutions.” *Computational Economics* 42(3):307–25. doi: 10.1007/s10614-012-9342-y.

Maliar, Serguei, Lilia Maliar, and Kenneth Judd. 2011. “Solving the Multi-Country Real Business Cycle Model Using Ergodic Set Methods.” *Journal of Economic Dynamics and Control* 35(2):207–28. doi: 10.1016/j.jedc.2010.09.014.

Malin, Benjamin A., Dirk Krueger, and Felix Kubler. 2011. “Solving the Multi-Country Real Business Cycle Model Using a Smolyak-Collocation Method.” *Journal of Economic Dynamics and Control* 35(2):229–39. doi: 10.1016/j.jedc.2010.09.015.

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Reiter, Michael. 2010. “Solving the Incomplete Markets Model with Aggregate Uncertainty by Backward Induction.” *Journal of Economic Dynamics and Control* 34(1):28–35. doi: 10.1016/j.jedc.2008.11.009.

Ruge-Murcia, Francisco J. 2007. “Methods to Estimate Dynamic Stochastic General Equilibrium Models.” *Journal of Economic Dynamics and Control* 31(8):2599–2636. doi: 10.1016/j.jedc.2006.09.005.

Villemot, Sébastien, and Sébastien Villemot. 2012. *Using an Endogenous Grid Method*.