ECON 525A: Computational Economics
Spring Quarter 2020

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The course covers a set of numerical methods that are used to compute and estimate economic models. We mainly study dynamic models and their applications in IO and labor economics, including dynamic discrete choice, dynamic games, two-step methods (CCP based methods), and general equilibrium models. We also cover several technical tools, such as methods for solving nonlinear equations, numerical integration, approximation, and optimization.

Reading. There is **no required textbook** for this course. During the lectures, I will mainly use expositions and examples from the following three textbooks:

1. Judd, K. (1998). *Numerical Methods in Economics*. The MIT Press.
2. Miranda, M. and Fackler, P. (2002). *Applied Computational Economics and Finance*. The MIT Press.
3. Heer, B. and Maussner, A. (2009). *Dynamic General Equilibrium Modeling*. Springer, 2nd edition.

You do **not** need to buy any of these textbooks. I will distribute class slides every week. Additional readings for each topic are listed below.

Lectures. Lectures will be held Tuesdays and Thursdays from 11:00am-12:20pm on Zoom.

Zoom. I will post the Zoom meeting ID on the Canvas announcement a few hours before each lecture.

Materials. Each week, class notes are posted on the course website at https://sites.google.com/site/yuyasweb/teaching/numerical. Homework assignments and notifications are also available there.

Grading. There will be **eight** problem sets, each of which accounts for one eighth of the course grade. Due dates for assignments will be announced later:

Homework 1: Solving linear/nonlinear equations
Homework 2: Computing the Ramsey growth model
Homework 3: Estimating a Rust (1987) type model
Homework 4: CCP methods
Homework 5: Computing a dynamic Markov game
Homework 6: Function approximation

Homework 7: Interpolation in a DDC model
Homework 8: Numerical derivative/integral

I strongly recommend you work as a group of several students, but each of you should write your own answer/code.

Office Hours. By appointment.

Outline Schedule (subject to change).

Week 1 (Mar. 31, Apr. 2) Linear and non-linear equations
- L-U factorization
- Iterative methods
- Newton and quasi-Newton methods

Week 2 (Apr. 7, 9) Dynamic programming I
- Math preparation
- Value function iteration, policy function iteration
- Optimal growth model
- Dynamic discrete choice

Week 3 (Apr. 14, 16) Dynamic programming II
- Rust (1987)
- Timmins (2002)

Week 4 (Apr. 21, 23) Optimization
- Comparison method
- Newton-Raphson method
- Stochastic search

Week 5 (Apr. 28, 30) CCP methods
- Hotz and Miller (1993)
- Hotz, Miller, Sanders and Smith (1994)

Week 6 (May 5, 7) Estimation of dynamic game
- Dynamic Markov game
- Two step methods: Pesendorfer and Schmidt-Dengler (2008), Bajari, Benkard, and Levin (2007), Aguirregabiria and Mira (2007)

Week 7 (May 12, 14) Function approximation
- Local approximation methods
- Interpolation methods
- Application to dynamic discrete choice models: Keane and Wolpin (1994)

Week 8 (May 19, 21) Numerical integration and differentiation

- Gaussian quadrature
- Random number generation
- Numerical differentiation

Week 9 (May. 26, 28) Heterogeneous agent GE model I

- Computing a stationary equilibrium
- Dynamics of a heterogeneous-agent model

Week 10 (Jun. 2, 4) Heterogeneous agent GE model II

- Aggregate uncertainty
- Application: Lee and Wolpin (2006)

Readings.

1. Aguirregabiria, V. and Mira, P. (2007). Sequential Estimation of Dynamic Discrete Games. *Econometrica* 75(1): 1-53.
2. Aiyagari, S. R. (1994). Uninsured Idiosyncratic Risk and Aggregate Saving. *Quarterly Journal of Economics* 109(3): 659–684.
3. Arcidiacono, P. and Miller, R. (2011). Conditional Choice Probability Estimation of Dynamic Discrete Choice Models with Unobserved Heterogeneity. *Econometrica* 79(6): 1823-1867.
4. Bajari, P., Benkard, L. and Levin, J. (2007). Estimating Dynamic Models of Imperfect Competition. *Econometrica* 75(5): 1331-70.
5. Ericson, R. and Pakes, A. (1995). Markov Perfect Industry Dynamics: A Framework for Empirical Work. *Review of Economic Studies* 62: 53-82.
6. Heiss, F. and Winschel, V. Likelihood approximation by numerical integration on sparse grids. *Journal of Econometrics* 144: 62-80.
7. Hotz, J. and Miller, R. (1993). Conditional Choice Probabilities and the Estimation of Dynamic Models, *Review of Economic Studies* 60 (3): 497-529.
8. Hotz, V., Miller, R., Sanders, S., and Smith, J. (1994). A Simulation Estimator for Dynamic Models of Discrete Choice. *Review of Economic Studies* 61(2): 265-289.
9. Keane, M. and Wolpin, K. (1994). The Solution and Estimation of Discrete Choice Dynamic Programming Models by Simulation and Interpolation: Monte Carlo Evidence. *The Review of Economics and Statistics* 76(4): 648-672.
10. Lee, D. and Wolpin, K. (2006). Intersectoral Labor Mobility and the Growth of the Service Sector. *Econometrica* 74(1): 1-46.
11. McFadden, D.L. (1999). Computing Willingness-to-Pay in random Utility Models, in Melvin, J.R., Moore, J.C. and R. Riezman (eds.): *Trade, Theory and Econometrics - Essays in Honor of John S. Chipman*, New York: Routlegde.
12. Pesendorfer, M. and Schmidt-Dengler, P. (2008). Asymptotic Least Squares Estimators for Dynamic Games. *Review of Economic Studies* 75(3): 901-928.
13. Pesendorfer, M. and Schmidt-Dengler, P. (2010). Sequential Estimation of Dynamic Discrete Games: A Comment. *Econometrica* 78(2): 833-842.

14. Rust, J. (1987). Optimal Replacement of GMC Bus Engines: An Empirical Model of Harold Zurcher. *Econometrica* 55(5): 999-1033.
15. Rust, J. (1994). Structural Estimation of Markov Decision Processes. In R. Engle and D. McFadden (eds.) *Handbook of Econometrics* Volume 4, 3082-3139, North Holland.
16. Seim, K. (2006). An Empirical Model of Firm Entry with Endogenous Product-Type Choices. *RAND Journal of Economics* 37(3): 619-640.
17. Timmins, C. (2002). Measuring the Dynamic Efficiency Costs of Regulators Preferences: Municipal Water Utilities in the Arid West. *Econometrica* 70(2): 603-629.