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HSE, St.Petersburg

“Dynamic programming and structural estimation”

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Syllabus

This short course covers the main numerical techniques in applied dynamic modeling in economics, and overviews the estimation methods used in empirical research based on these models. Utilizing the two classic models from applied IO and computational macro, we address both discrete and continuous choice settings, finite and infinite horizon dynamics, and a number of stochastic implementations. The lectures are accompanied by the practical lab sessions giving the students the essential hands-on experience in implementing the discussed methods in Python programming language.

Weekly hours	2 lectures + 2 labs		2 lectures + 1 lab		2 lectures + 1 lab	
Lecture	80 min	80 min	80 min	80 min	80 min	80 min
Lab (for each group)	80 min	80 min	-	80 min	-	80 min

Lecture 1

Introduction to dynamic discrete choice models

Bus engine replacement model (Zurcher model)

Dynamic programming, value function iterations (VFI) and policy iterations

📖 Rust, John (1987): “Optimal replacement of GMC bus engines: An empirical model of Harold Zurcher.” *Econometrica*, 55(5), 999–1033

Lecture 2

Maximum likelihood estimation of dynamic discrete choice models

Rust assumptions and estimation of dynamic discrete choice models

Nested fixed point (NFXP) estimator and algorithm

📖 Rust, John (2000): “Nested fixed point algorithm documentation manual. Version 6.” Available at https://editorialexpress.com/jrust/nfxp.html

📖 Iskhakov, F., J. Lee, J. Rust, B. Schjerning, B and K. Seo. (2016): “Constrained Optimization Approaches to Estimation of Structural Models: Comment.” *Econometrica*, 84(1), 365–370

Lab 1

Introduction to Python and Jupyter Notebooks
Installation and setup of computing environment
Version control
Essence of Python programming
Scientific packages (NumPy, SciPy, Pandas)

📖 QuantEcon online resource https://quantecon.org/quantecon-py/
📖 Kevin Sheppard "Introduction to Python for Econometrics, Statistics and Data Analysis." 3rd Edition University of Oxford Thursday 1st February, 2018 https://www.kevinsheppard.com/images/b/b3/Python_introduction-2016.pdf

Lab 2

Implementation of bus engine replacement model and NFXP
Comparing VFI and policy iteration solutions, NFXP and mathematical programming with equilibrium constraints (MPEC) approach

Lecture 3

Dynamic discrete choice models in choice probability space
Hotz-Miller inversion theorem
Conditional choice probabilities (CCP) estimator

📖 Hotz, V. J., and R. A. Miller. (1993): "Conditional choice probabilities and the estimation of dynamic models." *The Review of Economic Studies,* 60(3) 497-529.

Lecture 4

Swapping the NFXP algorithm
Nested pseudo-likelihood (NPL) estimator
CCP based estimators family

📖 Aguirregabiria, V., & Mira, P. (2002): "Swapping the nested fixed point algorithm: A class of estimators for discrete Markov decision models". *Econometrica*, 1519-1543.

Lab 3

Implementing and comparing various estimators for Zurcher model
Implementation of CCP and NPL estimators
Comparison of NFXP, MPEC, CCP, NPL estimators

Lecture 5

Dynamic models with continuous choice
Deaton consumption-savings model with borrowing constraint
Introducing idiosyncratic stochastic shocks
Solving Deaton model with VFI, time iterations, policy iterations
Endogenous gridpoint solution method

📖 Carroll, C. D. (2006): "The Method of Endogenous Gridpoints for Solving Dynamic Stochastic Optimization Problems," *Economics Letters*, 91(3), 312–320.

Lecture 6

Method of simulated moments estimation
Simulating data from the model
Assessing the accuracy of model solution, Keane's test
Weighting matrix for the moment conditions
Goodness of fit and diagnostics of model performance

📖 McFadden, Daniel (1989): "A method of simulated moments for estimation of discrete response models without numerical integration." *Econometrica*, 995–1026.
📖 French, Eric, and Jones, B.J. (2011): "The effects of health insurance and self-insurance on retirement behavior." *Econometrica*, 79(3), 693–732 (and online supplement!)

Lab 4

Implementing different solutions methods for Deaton model
VFI "on the grid", with discretized choice space, by optimizing over continuous choice
Policy iterations, time iterations and endogenous grid point method
Comparison of solution methods
Implementation of MSM estimator

Individual assignments:

Individual take home assignments are designed for final assessment of students' knowledge of the course materials, and should be completed within 7-10 days. The assignments will contain specific instructions, but will fall into the following general categories:

1. Comparative study of solution methods for Zurcher model
2. Monte Carlo study of estimation methods for Zurcher model
3. Empirical applications of NFXP estimator other than bus engine replacement
4. Empirical applications of CCP and NPL estimators
5. Nested general equilibrium models
6. Normative applications of dynamic models
7. Combining different data in MSM estimation

Topics for term projects:

1. Empirical applications of regenerative optimal stopping problems in industrial organization, labor, health and public economics
2. Verifying Rust assumptions in dynamic discrete structural econometrics models
3. Alternative specifications of dynamic discrete structural econometrics models
4. Comparative performance of different estimators of dynamic discrete choice models
5. Extending the dynamic discrete choice framework to game-theoretic setting
6. General equilibrium extensions to the dynamic discrete choice models
7. Uncertainty quantification with dynamic models
8. Dynamic discrete-continuous choice models
9. Assessing solution accuracy in dynamic discrete and continuous choice models
10. Welfare calculation in dynamic discrete and continuous choice models