Econ 525a (first half)
Yale University
Fall 2012
Prof. Tony Smith

Syllabus for Econ 525a:
Advanced Macroeconomics I (first half)

Course Objectives: The purpose of this half-course is twofold: first, to introduce students to computational tools for conducting numerical analysis of dynamic economic models; second, to introduce students to macroeconomic models with heterogeneous actors, which will serve as examples for the illustration of the computational tools.

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Office hours: Tuesdays from 10AM to noon

Course Meetings: The course meets on Mondays and Wednesdays from 1:30PM to 2:50PM in Room 108 (28 Hillhouse) until Monday, October 22.

Prerequisites: This course is designed for graduate students in economics who have taken first-year graduate courses in microeconomics, macroeconomics, and econometrics. No prior knowledge of either numerical methods or computer programming is assumed, but some familiarity with a programming language would prove helpful.

Course Requirements: The best (and really the only) way to learn numerical methods is to use them in actual problems. Accordingly, students must complete a series of problem sets that give them practice in using computational tools.

Texts: The lectures will be largely self-contained, but there are several good texts that provide useful complements to the material on numerical analysis taught in the lectures. An especially valuable book is: *Numerical Recipes in Fortran 77: The Art of Scientific*

Computing, Second Edition (Volume 1 of Fortran Numerical Recipes) by William H. Press, Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery (Cambridge University Press, 1992). This book is available online (for free) at: www.nrbook.com/a/bookfpdf.php. Its companion, *Numerical Recipes in Fortran 90: The Art of* Parallel *Scientific Computing, Second Edition* (Volume 2 of Fortran Numerical Recipes), is also available online at: www.nrbook.com/a/bookf90pdf.php. (Note: The third edition of *Numerical Recipes*, with code available entirely in *C++*, is available online too—with a paid subscription—at www.nr.com. The third edition covers a few more topics than the second edition, but its text overlaps substantially with the second edition.)

Other useful books include:

- *Applied Computational Economics and Finance* by Mario J. Miranda and Paul L. Fackler (MIT Press, 2002).
- *Numerical Methods in Economics* by Kenneth L. Judd (MIT Press, 1998).
- *Dynamic Economics: Quantitative Methods and Applications* by Jérôme Adda and Russell Cooper (MIT Press, 2003).
- *Computational Methods for the Study of Dynamic Economies*, edited by Ramon Marimon and Andrew Scott (Oxford University Press, 1999).
- *Handbook of Computational Economics (Volume 1)*, edited by Hans M. Amman, David A. Kendrick, and John Rust (North-Holland, 1996).
- *Dynamic General Equilibrium Modelling: Computational Methods and Applications*, by Burkhard Heer and Alfred Maussner (Springer, 2005).

APPROXIMATE LIST OF TOPICS

Week 1

Introduction (built around some simple examples from economics, including the stochastic-growth model and a canonical consumption-savings model).

General considerations in numerical analysis: convergence, roundoff error, truncation error.

Numerical differentiation.

Root-finding in one or more dimensions: bisection, secant method, Newton's method, fixed-point iteration, Gauss-Jacobi, Gauss-Seidel, Brent's method.

Suggested readings:

Chapters 1, 5.7, and 9 in *Numerical Recipes*; Appendix 2A, Chapter 3, and Chapter 5.6 in Miranda and Fackler; Chapters 1, 2, 5, and 7.7 in Judd.

Huggett, M. (1993), "The Risk-Free Rate in Heterogeneous-Agents, Incomplete Markets Economies," *Journal of Economic Dynamics and Control* 17, 953–969.

Taylor, J.B. and H. Uhlig (1990), "Solving Nonlinear Stochastic Growth Models: A Comparison of Alternative Solution Methods," *Journal of Business and Economic Statistics* 8, 1–18.

Week 2

Minimization in one or more dimensions: golden section search, Brent's method with or without derivatives, simplex method, Newton-Raphson, variable metric methods.

Suggested readings: Chapter 10 in *Numerical Recipes*; Chapter 5 in Miranda and Fackler; Chapter 4 in Judd.

Week 3

Interpolation and approximation of functions: linear interpolation in several dimensions, cubic splines, polynomial interpolation, orthogonal polynomials.

Suggested readings: Chapters 3 and 6 in *Numerical Recipes*; Chapter 5 in Miranda and Fackler; Chapter 6 in Judd.

Week 4

Numerical integration: cubic spline integration, Gaussian quadrature, Monte Carlo integration, integration of multivariate normal densities.

Suggested readings: Chapters 4 and 7 in *Numerical Recipes*; Chapter 5 in Miranda and Fackler; Chapters 7 and 8 in Judd.

Week 5

Numerical dynamic programming: value iteration, Euler equation methods, rules of thumb, perturbation methods, parameterized expectations, linear-quadratic (first-order) and second-order methods.

Suggested readings:

Chapters 7, 8, and 9 in Miranda and Fackler; Chapters 12, 13, 16, and 17 in Judd.

Aldrich, E., J. Fernández-Villaverde, A.R. Gallant, and J.F. Rubio-Ramírez (2011), "Tapping the Supercomputer Under Your Desk: Solving Dynamic Equilibrium Models with Graphics Processors," *Journal of Economic Dynamics and Control* 35, 386–393.

Benitez-Silva, H., G. Hall, G. Hitsch, G. Pauletto, and J. Rust (2005), "A Comparison of Discrete and Parametric Approximation Methods for Continuous-State Dynamic Programming Problems," manuscript (ms.cc.sunysb.edu/∼hbenitezsilv/dpa2005.pdf).

Christiano, L.J. and J.D.M. Fisher (2000), "Algorithms for Solving Dynamic Models with Occasionally Binding Constraints," *Journal of Economic Dynamics and Control* 24, 1179–1232.

Coleman, W.J. II (1990), "Solving the Stochastic Growth Model by Policy Function Itera-

tion," *Journal of Business and Economic Statistics* 8, 27–29.

Kim, J., S. Kim, E. Schaumburg, and C.A. Sims (2008), "Calculating and Using Second Order Accurate Solutions of Discrete Time Dynamic Equilibrium Models," *Journal of Economic Dynamics and Control* 32, 3397–3414.

Schmitt-Grohé, S. and M. Uribe (2004), "Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function," *Journal of Economic Dynamics and Control* 28, 755–775.

Smith, Jr., A.A. (1991), "Solving Stochastic Dynamic Programming Problems Using Rules of Thumb," Queen's University Discussion Paper No. 816.

Uhlig, H. (1999), "A Toolkit for Analysing Nonlinear Dynamic Stochastic Models Easily," in: *Computational Methods for the Study of Dynamic Economies*.

Weeks 6 and 7

Computation of dynamic equilibrium models with heterogeneous actors.

Suggested readings:

Aiyagari, S.R. (1994), "Uninsured Idiosyncratic Risk and Aggregate Saving," *Quarterly Journal of Economics* 109, 659–684.

Berger, D. (2012), "Countercyclical Restructuring and Jobless Recoveries" (https://sites.google.com/site/davidwberger/research).

Chatterjee, S. (1994), "Transitional Dynamics and the Distribution of Wealth in a Neoclassical Growth Model," *Journal of Public Economics* 54, 97–119.

Chien, Y., H. Cole, and H. Lustig (2011), "A Multiplier Approach to Understanding the Macro Implications of Household Finance," *Review of Economic Studies* 78, 199–234.

Den Haan, W.J. (2010), "Comparison of Solutions to the Incomplete Markets Model with Aggregate Uncertainty," *Journal of Economic Dynamics and Control* 34, 4–27.

Guvenen, M.F. (2009), "A Parsimonious Macroeconomic Model for Asset Pricing," *Econometrica* 77, 1711–1750.

Hopenhayn, H. and R. Rogerson (1993), "Job Turnover and Policy Evaluation: A General Equilibrium Analysis," *Journal of Political Economy* 101, pp. 915–938.

Huggett, M. (1996), "Wealth Distribution in Life-Cycle Economies," *Journal of Monetary Economics* 38, 469–494.

Khan, A. and J.K. Thomas (2002), "Nonconvex Factor Adjustments in Equilibrium Business Cycle Models: Do Nonlinearities Matter?", *Journal of Monetary Economics* 50, 331–360.

Khan, A. and J.K. Thomas (2003), "Inventories and the Business Cycle: An Equilibrium Analysis of (S,s) Policies," *American Economic Review* 97, 1165-1188.

Krueger, D. and F. Kubler (2003), "Computing Equilibrium in OLG Models with Stochastic Production," *Journal of Economic Dynamics and Control* 28, 1411–1436.

Krusell, P. and A.A. Smith, Jr. (1997), "Income and Wealth Heterogeneity, Portfolio Selection, and Equilibrium Asset Returns," *Macroeconomic Dynamics* 1, 387–422.

Krusell, P. and A.A. Smith, Jr. (1998), "Income and Wealth Heterogeneity in the Macroeconomy," *Journal of Political Economy* 106, 867–896.

Krusell, P., T. Mukoyama, A. Şahin, and A.A. Smith, Jr. (2009), "Revisiting the Welfare Effects of Eliminating Business Cycles" *Review of Economic Dynamics*, 12, 393–404.

Kubler, F. and K. Schmedders (2005), "Approximate versus Exact Equilibria in Dynamic Economies," *Econometrica* 73, 1205–1235.

Reiter, M. (2009), "Solving Heterogenous Agent Models by Projection and Perturbation," *Journal of Economic Dynamics and Control* 33, 649–665.

Reiter, M. (2009), "Approximate and Almost-Exact Aggregation in Dynamic Stochastic Heterogeneous-Agent Models," manuscript (elaine.ihs.ac.at/∼mreiter/appraggr.pdf).

Ríos-Rull, J.V. (1999), "Computation of Equilibria in Heterogeneous-Agent Models," in: *Computational Methods for the Study of Dynamic Economies*.

Rodríguez, S.B., J. Díaz-Giménez, V. Quadrini, and J.-V. Ríos-Rull (2002), "Updated Facts on the U.S. Distributions of Earnings, Income, and Wealth," *Federal Reserve Bank of Minneapolis Quarterly Review* 26 (No. 3), 2–35.

Telmer, C., K. Storesletten, and A. Yaron (2007), "Asset Pricing with Idiosyncratic Risk and Overlapping Generations," *Review of Economic Dynamics* 10, 519–548.

Thomas, J.K. (2002), "Is Lumpy Investment Relevant for the Business Cycle?" *Journal of Political Economy* 110, 508–534.

Vavra, J. (2012), "Inflation Dynamics and Time-Varying Uncertainty: New Evidence and an Ss Interpretation" (https://sites.google.com/site/jvavra/research).