Computational Methods for Macroeconomics (Spring 2008)

1 Basic Information

Instructor	Makoto Nakajima
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Course web site	`http://www.compmacro.com/makoto/200801econ552/index.php`
Office hours	Wednesdays 10:00-12:00 or by appointment (email me)
Class	Tuesdays & Thursdays, 11:00-12:20
Classroom	174 Wohlers Hall

2 Course Description

In the course, you will learn how the numerical and computational methods are used with various dynamic general equilibrium models. Specifically, there are four goals: (1) learn the basics of numerical methods, (2) learn how numerical and computational methods are used to solve models which do not have an analytical solution, (3) learn how the models can be calibrated or estimated so as to be used to answer quantitative questions, and (4) get familiar with variety of dynamic general equilibrium models which are used to answer variety of interesting questions.

There are two parts of the course. In The first part, you will learn how to solve, numerically and computationally, standard dynamic general equilibrium models which are widely used in macroeconomics. Regarding the goals, the first part covers the goals (1), (2), and (3). There will be some problem sets, which give you enjoyable (not painful!) chances of learning-by-doing.

In the second part of the course corresponds to the goal (4). Interesting recent papers which use the tools we cover in the first part of the course are presented and discussed. You will learn how the numerical and computational methods are used to answer variety of interesting questions in macroeconomics.

This is a Ph.D. course. The ultimate goal is to get you ready to start producing instead of consuming. I hope that the course helps you immediately start working on your own project once you have some interesting questions to be answered.

3 Prerequisites

1. Students need to have completed the first two sequences of Ph.D. macro courses (Macroeconomic Theory I and II).

2. Students need to have a basic knowledge in writing programs in one of the languages used for scientific computing (Fortran, C, Matlab, Gauss, Octave, Scilab, R, etc). If you want to do serious research in this field, learn fast languages, either Fortran 90 (or later) or C. If these languages are too intimidating, you could start with more user-friendly and popular languages like Matlab (or its freeware siblings, Octave, Scilab, or FreeMat) or R (becoming more and more popular among econometricians, and there's no reason macroeconomists do not use it).

4 Grading Policy

There are three requirements for satisfactorily completing the course:

1. **Problem Sets (60% of the final grade):** There will be six problem sets. All or most of them require writing small codes. I hope your experiences to write baby codes help you feeling comfortable in starting your own project immediately.
2. **Original Research Proposal (40% of the final grade):** You need to submit a written proposal of an original project for which you can use the tools acquired in the course. You are expected to *(i)* survey (at least a couple of) important papers related to your research project, *(ii)* come up with a question that requires the tools acquired in the course to answer, *(iii)* write down the model, *(iv)* state computational algorithm and mention challenges in computation, if any. I am very happy to help you if you would like to keep on working on the project.
3. **Attend our awesome macro seminar!**

5 Textbooks

There is no main textbook that I will closely follow. However, there are some books which are useful for this course, and for you future research. Below is the list.

1. **Press et al. (2001):** Extremely useful book collecting various codes for numerical operations. Also there is a C language version. Available on-line.
2. **Heer and Maussner (2005):** Closest to the approach of the course, with a lot of examples.
3. **Judd (1998):** Dictionary of computational methods that are useful for economists.
4. **Marimon and Scott, eds (1999):** Collection of papers covering various branches of computational methods concisely.
5. **Ljungqvist and Sargent (2004):** Standard textbook in macroeconomics.
6. **Cooley, ed (1995):** Collection of papers on business cycles, occasionally mentions computational methods.
7. **Miranda and Fackler (2002):** Relatively new textbook. Focusing more on finance and spending considerable amount of pages on continuous time methods.
8. **Ada and Cooper (2003):** Concise introduction on solving a dynamic model and estimating structural parameters of the model.

6 Course Outline

1. **Numerical Methods**
   (a) Function approximation (discretization, finite element, weighted residuals, chebyshev).
   (b) Optimization (one-dimensional, multi-dimensional, Genetic algorithm).
   (c) Root-finding (one-dimensional, multi-dimensional).
   (d) Numerical differentiation and integration.
   (e) Shooting algorithm.
2. **Topics for Solving Dynamic Macroeconomic Models**
   (a) Value function iteration.
   (b) Policy function iteration (Euler Equation Method).
   (c) Linear-Quadratic (L-Q) approximation.
   (d) Local approximation (Linearized Euler Equation, Perturbation).
   (e) Global approximation of value function or policy function.
   (f) Parameterized Expectation Approximation (PEA).
   (g) Assessing error of approximation.
   (h) Approximating AR(1) process with Markov chain.
   (i) Endogenous grid point method.
   (j) Approximating type distribution of heterogeneous agents.
   (k) How to calibrate/estimate?
   (l) Parallel computation.
3. **Basic Models**
   (a) Growth model.
   (b) Overlapping-generations model (OLG).
   (c) RBC/DSGE model (stochastic growth model).
   (d) Aiyagari's (1994) model (Growth model with idiosyncratic uncertainty).
   (e) OLG model with idiosyncratic uncertainty (Huggett (1996)).
   (f) Models with transition between steady states.
   (g) Models with idiosyncratic and aggregate uncertainty (Krusell and Smith (1998)).
4. **Applications**
   (a) Aggregation: (ir-)relevance of market incompleteness.
   (b) Asset pricing with market incompleteness.
   (c) Labor market friction.
   (d) Endogenous human capital accumulation.
   (e) Limited enforcement: default and bankruptcy.
   (f) Fiscal policy with heterogeneous agents.

References

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Aiyagari, S. Rao, "Uninsured Idiosyncratic Risk and Aggregate Saving," *Quarterly Journal of Economics*, 1994, *109* (3), 659–684.

Cooley, Thomas F., ed., *Frontiers of Business Cycle Research*, Princeton, NJ: Princeton University Press, 1995.

Heer, Burkhard and Alfred Maussner, *Dynamic General Equilibrium Modelling*, Heidelberg: Springer, 2005.

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

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Ljungqvist, Lars and Thomas Sargent, *Recursive Macroeconomic Theory*, Cambridge, MA: MIT Press, 2004.

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Miranda, Mario J. and Paul L. Fackler, *Applied Computational Economics and Finance*, Cambridge, MA: MIT Press, 2002.

Press, William H., Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery, *Numerical Recpes in Fortrn 77. Second Edition. The Art of Scientific Computing*, Cambridge: Cambridge University Press, 2001.