Computational Methods for Macroeconomics (Spring 2007)

1 Basic Information

Instructor	Makoto Nakajima
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Course web site	`http://www.compmacro.com/makoto/200701econ552/index.php`
Office hours	Wednesdays 10:00-12:00 or by appointment (email me)
Class	Tuesdays & Thursdays, 12:30-13:50
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. I expect some of the papers are presented by students. 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, after completing the course, you can 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. Otherwise, Matlab (or its freeware siblings, Octave and Scilab) or R (becoming more and more popular among econometricians, and there's no reason macroeconomists do not use it) are the most popular and safe bet.

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. **Student Presentations (20% of the final grade):** Each of you are asked to make a 90 minutes presentation of a paper that you choose from the list in this syllabus. Alternatively, you can pick a paper of your interest. You are expected to present the summary of the findings of the paper, make a critical evaluation of the paper, and explain the computational methods, including the solution algorithm, used in the paper. The presentations are in the second part of the course. If you decide to take this course, please let me know by email which paper you want to present.
3. **Original Research Proposal (20% of the final grade):** By the last day of the class, 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 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.

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) (HS):** 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) (MS):** Collection of papers covering various branches of computational methods concisely.
5. **Ljungqvist and Sargent (2004):** Standard textbook in macroeconomics.
6. **Cooley, ed (1995) (CO):** 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) (AC):** Concise introduction on solving a dynamic model and estimating structural parameters of the model.

6 Course Outline

Part I: Numerical and Computational Methods for Solving Macroeconomic Models

1. Introduction: Neoclassical Growth Model (representative agent + no uncertainty)
   (a) Overview of methods.
   (b) Solution methods
      i. Value function iteration + discretization.
      ii. Value function iteration + finite element method.
      iii. Policy function iteration + finite element method.
      iv. Speed-up tricks: Using properties of the value functions and policy functions. Howard algorithm.
   (c) Numerical methods
      i. Finite element method (piecewise linear, cubic spline, shape-preserving spline).
      ii. One-dimensional optimization.
      iii. One-dimensional root-finding.
   (d) Extensions of the basic model
      i. Labor-leisure choice.
2. Real Business Cycle Model (representative agent + aggregate uncertainty)
   (a) The motivating question: Kydland and Prescott (1982)
   (b) Solution methods
      i. Linear-Quadratic (LQ) approximation. HS 2.2, MS 2.
      ii. Linearizing Euler Equations. HS 2.3, MS 3, Uhlig (1997), Klein (2000).
      iii. Perturbation (Higher order approximation). Jin and Judd (2002), Arouba et al. (2006).
      iv. Parameterized Expectation Approach (PEA) HS 3, MS 7.
      v. Global approximation (discretization, and approximation of value function or optimal decision rule function)
      vi. Models with binding constraints
   (c) Calibration and Estimation: CO 1, Ireland (2004).
   (d) Numerical methods
      i. Numerical integration: Newton-Coates, adaptive, Gaussian, Monte-Carlo, Tauchen (1986), Tauchen and Hussey (1991).
      ii. Weighted residual method.
      iii. Chebyshev regression.
      iv. Multi-dimensional optimization.

(e) Extensions of the basic model

i. Labor market search.
ii. Monetary economy.
iii. Time to build.
iv. Irreversible investment.

3. Aiyagari (1994) Model (Infinitely-lived agents + uninsured idiosyncratic shocks)

(a) The motivating question: Domeji and Heathcote (2004).

(b) Solution method of the basic model: Aiyagari (1994), MS 11, HS 5.

i. Solving individual optimal decision rule: discretization, approximating value function or optimal decision rule.
ii. Approximating the type distribution.
iii. Finding the stationary distribution.
iv. Finding a set of equilibrium prices.

(c) Endogenous Grid points Method: Carroll (2006), Barillas and Fernandez-Villaverde (2006).

(d) Calibration and Estimation: Chatterjee et al. (2005), Gourinchas and Parker (2002), Cagetti (2003).

(e) Extensions of the basic model

i. Demographics.
ii. Labor-leisure choice.
iii. Model with housing.
iv. Model with Habit.
v. Model with Human capital accumulation.

(f) Model with transition: Domeji and Heathcote (2004), MS 11, HS 6.2.

(g) Model with aggregate uncertainty: Krusell and Smith (1998), Krusell and Smith (1997), MS 11, HS 6.3.

4. Huggett (1996) Model (Finitely-lived agents + uninsured idiosyncratic shocks)

(a) The motivating question: Conesa and Krueger (1999).

(b) Solution method of the basic model: Huggett (1996), HS 7.2.

(c) Extensions of the basic model

(d) Model with transition: Conesa and Krueger (1999), Heathcote et al. (2003), HS 7.2.

(e) Model with aggregate uncertainty: Ríos-Rull (1996), Storesletten et al. (2001a), HS 7.2.

Part II: Applications

1. **Labor market search:** Lise (2006), Reichling (2007), Veracierto (2002)
2. **Optimal savings level:** Aiyagari (1994), Davila et al. (2005), Pijoan-Mas (2006)
3. **Fiscal policy:** Domeji and Heathcote (2004) Heathcote (2005), Aiyagari and McGrattan (1998), Conesa et al. (2006)
4. **Social security reform:** Conesa and Krueger (1999), Huggett and Ventura (1999)
5. **Monetary policy:** Erosa and Ventura (2002), Bai (2005)
6. **Costs of business cycles:** Lucas (2003), Krusell and Smith (1999), Storesletten et al. (2001b), Costain and Reiter (2005)
7. **Wealth inequality:** Chatterjee (1994), Díaz-Giménez et al. (1997), Castañeda et al. (2003), De Nardi (2004)
8. **Entrepreneurship:** Quadrini (2000), Meh and Quadrini (2006), Michelacci and Quadrini (2004)
9. **Asset pricing and stock market non-participation:** Kocherlakota (1996), Krusell and Smith (1997), Storesletten et al. (2001a), Pijoan-Mas (2004), Constantinides et al. (2002), Guvenen (2004), Guvenen (2005)
10. **Macroeconomic effect of rising earnings inequality:** Heathcote et al. (2003), Krueger and Perri (2003), Krueger and Perri (2005), Guvenen and Kuruscu (2005), Huggett et al. (2005)
11. **Default and bankruptcy:** Chatterjee et al. (2002), Alvarez and Jermann (2000), Livshits et al. (2005b), Livshits et al. (2005a), Yue (2005), Narajabad (2006)
12. **Housing or durable goods:** Fernández-Villaverde and Krueger (2005), Jeske and Krueger (2005) Díaz and Luengo-Prado (2003), Nakajima (2005), Ortalo-Magné and Rady (2005)
13. **Family economics:** Cubeddu and Ríos-Rull (2003), Guner and Knowles (2003), Caucutt et al. (2002)
14. **Political economy:** Krusell et al. (1997), Krusell and Ríos-Rull (1999), Corbae et al. (2006)

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