Universitat Pompeu Fabra Barcelona

Advanced Techniques in Macroeconomics I

2019-2020 Academic Year
Master of Research in Economics, Finance and Management

1. Description of the subject

- Advanced Techniques in Macroeconomics I
- Total credits: 6 ECTS

Code: 31804
Workload: 150 hours
Term: 1st

- Type of subject: Optative
- Department of Economics and Business
- Teaching team: Edouard Schaal

2. Teaching guide

Objective

The main objective of this course is to equip the student with state-of-the-art numerical techniques that can be used to answer important questions in quantitative macroeconomics. The course has three parts. In the first part, I will teach basic numerical methods (rootfinding, optimization, etc.). In part two, we will study the general principles behind important classes of resolution methods (perturbation and projection methods) with applications to standard dynamic macroeconomic models (neoclassical growth, RBC, NK). In the third part of the course, I will put greater emphasis on heterogeneous agent models and the specific techniques they require.

Contents

1. **Basics of numerical analysis.**
   Numerical differentiation and Integration. Rootfinding. Unconstrained and Constrained Optimization.
   Applications: The Diamond-Mortensen-Pissarides model.
   Deterministic Ramsey growth model.

2. **Perturbation Methods.**
   Linearization. Higher-order perturbation. Pruning. Dynare.
   Application: Medium-scale DSGE models.
   Models with Occasionally Binding Constraints.

3. **Discretization.**
   Discretization of stochastic processes. Value function and policy function iteration. Howard improvement. Endogenous grid method.
   Application: the Income Fluctuation problem.

4. **Projection Methods.**
   Finite elements (linear and cubic splines). Spectral methods (Chebyshev polynomials). Colocation. Smolyak quadrature.
   Application: RBC model.

5. **Heterogeneous Households: Bewley-Huggett-Aiyagari models.**
   Model definition. Distribution invariants.

6. **Aggregate Uncertainty in Heterogeneous-agent Economies.**
   Transitional dynamics. Krusell and Smith (1998). Reiter (2009). Boppart, Krusell and Mitman (2018). Le Grand and Ragot (2018).

7. **Heterogeneous Firms.**
   Hopenhayn (1992). Kahn and Thomas (2008). Winberry (2016)

8. **Life-Cycle Economies.**
   Storesletten, Telmer and Yaron (2004).

9. **Topics in Heterogeneous-agent Economies.**
   Time permitting: Wealthy Hand-to-Mouth (Kaplan, Violante and Weidner, 2014). HANK (Kaplan, Moll and Violante, 2018).

Teaching methodology

Approach and general organization of the subject

The focus of the course will be on the numerical solution of macroeconomic models, as a complement to the theoretical aspects covered in other courses (e.g. Topics in Macroeconomics, International Economics, Topics in Corporate Finance). Previous knowledge of specific models is not required, as they will be described in class, or specific notes will be distributed. However, students should be familiar with general concepts of dynamic models, as taught for example in Macroeconomics or Advanced Macroeconomics courses.

For each topic covered, lectures will be divided into the following parts: (i) theoretical description of the numerical technique; (ii) application of the technique to a standard model; (iii) application of the technique to specific models (see list above).

This is not a course about computer languages. Students will have to learn how to write computer programs to implement the techniques discussed in class using whichever language they like (MATLAB, Fortran, C, Julia, Python, etc.). The programming language used in the course will be MATLAB. Basic knowledge of MATLAB (or another programming language) is highly recommended. Students who are serious about computing may want to use this course as an opportunity to learn more advanced languages (Fortran, C, Python or Julia).

Training activities

Lectures, proposed readings, study and development of computer programs.

Assessment and Grading System

The grade of the course will be determined on the following basis:

- (40%) A short final exam, about the theoretical concepts and algorithms covered during lectures.
- (40%) A series of homeworks, requiring to write computer programs to solve standard problems and models. Homeworks could be performed in small groups (max. 3 people, one solution per group).
- (20%) Time permitting: possibly a 10-15 min presentation of a paper covering a recent topic in heterogeneous agent modeling towards the end of the course.

Textbook and References

My slides are the main resource for this course. They will be regularly posted on Box. They build on a previous course taught at NYU from 2012-2016 and lectures notes by Davide Debortoli and Gianluca Violante.

Important references for the **numerical techniques** covered in class is the book

Miranda, M. J. and Fackler, P. L. (2002), *Applied Computational Economic and Finance*, MIT Press (henceforth MF).

Judd, K. L. (1998), *Numerical Methods in Economics*, MIT Press, Cambridge and London.

Other valuable resources are:

Sargent, T. and Stachurski, J. (2019), *Lectures in Quantitative Economics*, https://lectures.quantecon.org/.

Other references for **numerical methods for macroeconomic models** are

Algan Y., O. Allais, W. Den Haan and P. Rendal (2014), "Solving and Simulating Models with Heterogeneous Agents and Aggregate Uncertainty", *Handbook of Computational Economics,* Vol. 3, Ch. 6.

Fernandez-Villaverde J. and J. Rubio Ramirez (2016), "Solution and Estimation Methods for DSGE Models", *Handbook of Macroeconomics,* Vol. 2.

Guerrieri, L. and M. Iacoviello (2015), "OccBin: A toolkit for solving dynamic models with occasionally binding constraints easily", *Journal of Monetary Economics*, 70, 22-38.

Maliar L. and S. Maliar, (2014). "Numerical Methods for Large Scale Dynamic Economic Models" in: Schmedders, K. and K. Judd (Eds.), Handbook of Computational Economics, Volume 3, Chapter 7, 325-477, Amsterdam: Elsevier Science.

Marcet, A. and G. Lorenzoni, (1998), "Parametrized expectations approach: some practical issues", in R. Marimon and A. Scott (eds), *Computational Methods for the Study of Dynamic Economies*, Oxford University Press.

Ragot, X. (2017) "Heterogeneous agents in the Macroeconomy: Reduced-heterogeneity representations", working paper, SciencesPo.

Sims, C. A. (2001), "Solving linear rational expectations models", *Computational Economics* 20(1-2), 1-20.

References for specific **applications** are:

Aiyagari, S. R. (1994). Uninsured idiosyncratic risk and aggregate saving. *The Quarterly Journal of Economics*, *109*(3), 659-684.

Boppart, T., Krusell, P., & Mitman, K. (2018). Exploiting MIT shocks in heterogeneous-agent economies: the impulse response as a numerical derivative. *Journal of Economic Dynamics and Control*, *89*, 68-92.

Fernández-Villaverde, J. , G. Gordon, P. Guerrón-Quintana and J. Rubio-Ramírez (2015). "Nonlinear adventures at the zero lower bound," *Journal of Economic Dynamics and Control*, 57(C), 182-204.

Floden, Martin (2001), The Effectiveness of Government Debt and Transfers as Insurance, *Journal of Monetary Economics*.

Hopenhayn, H. A. (1992). Entry, exit, and firm dynamics in long run equilibrium. *Econometrica: Journal of the Econometric Society*, 1127-1150.

Huggett, M. (1993). The risk-free rate in heterogeneous-agent incomplete-insurance economies. *Journal of economic Dynamics and Control*, *17*(5-6), 953-969.

Kaplan, G., Moll, B., & Violante, G. L. (2018). Monetary policy according to HANK. *American Economic Review*, *108*(3), 697-743.

Kaplan, G., Violante, G. L., & Weidner, J. (2014). The Wealthy Hand-to-Mouth. *Brookings Papers on Economic Activity*, *2014*(1), 77-138.

Khan, A., & Thomas, J. K. (2008). Idiosyncratic shocks and the role of nonconvexities in plant and aggregate investment dynamics. *Econometrica*, *76*(2), 395-436.

Krueger, D., and Kubler, F. (2004). "Computing equilibrium in OLG models with stochastic production." Journal of Economic Dynamics and Control 28.7: 1411-1436.

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

Le Grand, F., & Ragot, X. (2018). A class of tractable incomplete-market models for studying asset returns and risk exposure. *European Economic Review*, *103*, 39-59.

McKay, A., E. Nakamura, and J. Steinsson (2016) "The Power of Forward Guidance Revisited", *American Economic Review*, 106(10): 3133-58.

Mortensen, D. and C. A. Pissarides, (1994) "Job Creation and Job Destruction in the Theory of Unemployment", *Review of Economic Studies*, vol. 61(3), 397-415.

Reiter, M. (2009). Solving heterogeneous-agent models by projection and perturbation. *Journal of Economic Dynamics and Control*, *33*(3), 649-665.

Smets, F. and R. Wouters, (2007). "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach", *American Economic Review*, American Economic Association, 97(3), 586-606.

Storesletten, Kjetil, Chris I. Telmer, and Amir Yaron. "How important are idiosyncratic shocks? Evidence from labor supply." The American Economic Review 91.2 (2001): 413-417.

Storesletten, Kjetil, Christopher I. Telmer, and Amir Yaron. "Consumption and risk sharing over the life cycle." Journal of Monetary Economics 51.3 (2004): 609-633.

Winberry, T. (2016). A toolbox for solving and estimating heterogeneous agent macro models. *Quantitative Economics*.