

Computational Macroeconomics

(Optional Course, 4 credits)

Soumya Datta
soumya@econ.sau.ac.in

Lectures: Thu: 11am-1pm & Fri: 2-4 pm (ES 303)

Office: ES 208

Google Classroom:

Class code: evfgqvau

Link: <https://classroom.google.com/c/NzcxMTA4MjM2NDIz?cjc=evfgqvau>

Course Description

This is a hands-on course on a computational approach to macroeconomic modelling, offered to 3rd semester Masters' and 1st semester doctoral students. The course equips students with using computer programming languages like *Python*, *MATLAB* and *Julia* to develop, calibrate and solve (both analytically and numerically) several contemporary macroeconomic models. The course begins with programming basics, and covers several standard computational tools which are part of the toolbox of modern macroeconomists. We use contemporary macroeconomic models, including neoclassical models with both representative and heterogeneous agents, search and matching, as well as some behavioral and Post Keynesian models. Many of these models are analytically intractable, requiring numerical methods, which will be taught in this course. We will also learn how to process and interpret some standard macroeconomic datasets.

Softwares

The course will try to equip you with basic skills in at least three programming languages: *Python*, *Julia* and *MATLAB / Octave*. In addition, by the end of the course you will also be expected to independently use at least one of these languages to write your own codes to solve various computational problems. Initial lectures will show you how to install and set up *Python* and *Julia* on your computer and use *JupyterLab* to write codes in these languages. Sessions in *MATLAB*, which is a proprietary (and expensive) software, will be conducted in the Computer Lab. The macroeconomic models will be typically developed in the class using one of these languages. The students will have the option of choosing any of the three programming languages for completing the problem sets (except the language-specific problems) and the project at the end of the semester. In addition, this course will also introduce you to *DYNARE*, which is a *MATLAB*-based package to solve, calibrate and simulate dynamic general equilibrium models.

Prerequisites

No prior background in programming is required, as programming basics will be taught as a part of this course. The foundation for this course has already been provided in the core courses in the first two semesters.

Evaluation

Problem sets / Projects: 20%, Mid-semester Examination (in-person with computer): 40%, End-semester Examination (in-person with computer): 40%.

Course Outline*

1 The Computational Experiment

A big picture of what we cover in this course, and why do we do this.

Reference: Lucas (1980), Kydland and Prescott (1996).

2 Programming Basics: Python, MATLAB & Julia

Introduction to programming, algorithm & pseudocodes. Introduction to Python, using Jupyter Lab / Notebook. Setting up your Python environment. Scripts, loops, functions, structures and classes. Object Oriented Programming. Using Scientific Libraries in Python: NumPy, Matplotlib, SymPy, SciPy, Numba, Parallelization, Pandas etc. Introduction to MATLAB / GNU Octave. Introduction to Julia, using Jupyter Lab / Notebook. Managing, processing & visualizing macroeconomic data. Linear Algebra through symbolic computation.

Reference: [Sargent and Stachurski's Python lectures](#), MATLAB User guides, *[Perla, Sargent and Stachurski's Julia lectures](#), *Stachurski (2009), *Novales, Fernández, and Ruiz (2014).

3 Economic Dynamics using Python / MATLAB / Julia

Dynamic models in discrete and continuous time: deterministic and stochastic time series models: Analytically and numerically solving / simulating difference and differential equations. Approximation methods: Newton's method, Differential equation solvers: Runge-Kutta algorithm for solving ODE in Python & MATLAB. AR(1) processes, measuring business cycles from the data.

Reference: [Sargent and Stachurski's Python lectures](#), MATLAB User guides, [Perla, Sargent and Stachurski's Julia lectures](#), Judd (2023) chapt. 5-7, *Stachurski (2009).

4 Dynamic Programming

Deterministic finite and infinite horizon problems, value functions, Bellman equation and policy functions, existence and uniqueness of value functions, solving by sequential method vs. dynamic programming using value function iteration, introduction to stochastic processes and Markov chains, optimal stopping problems, stochastic dynamic programming.

Reference: [Sargent and Stachurski's Python lectures](#), Adda and Cooper (2003) chapt. 2, Ljungqvist and Sargent (2012) chapt. 2 & 3, Judd (2023) chapt. 5-7.

* Starred readings are optional

5 Representative Agent Models

5.1 DSGE models and Real Business Cycles

Arrow-Debreu Competitive Equilibrium, Sequential Trading Competitive Equilibrium, Recursive Competitive Equilibrium. Moving from theory to data. Calibration techniques. Simulation of artificial economy using Dynare (MATLAB) / linearsolve (Python). Generating impulse response from a technology shock. *Reference:* Adda and Cooper (2003) chapt. 5, Cooley (1995) chapt. 1, Heer and Maußner (2008), *Brock and Mirman (1972), *Uribe and Schmitt-Grohé (2017) chapt. 4, *McCandless (2008) chapt. 4 to 7, *Summers (1990), *Kydland and Prescott (1982), *King and Rebelo (1999).

5.2 New Keynesian Model

Nominal wage rigidities, New Keynesian model, simulations using Dynare / linearsolve, computational experiments with exogenous shocks, policy applications.

Reference: Galí (2008) chapt. 3, Heer and Maußner (2008), chapt. 2, Smets and Wouters (2003).

6 Heterogeneous Agent Models & Wealth Inequality

Models with infinitely-lived agents subject to uninsurable idiosyncratic risks: Bewley-Aiyagiri models, income and wealth inequality and distribution dynamics, limited asset market participation, HANK / TANK models with poor hand-to-mouth agents.

Reference: Heer and Maußner (2008), *Ljungqvist and Sargent (2012), *Krueger, Perri, Pistaferri, and Violante (2010), *Aiyagiri (1994), *Krusell, Smith, and Anthony (1998), *Bilbiie (2008).

7 Search and Matching in Labor Market

Diamond-Mortensen-Pissarides model: matching function, job creation, Beveridge curve, wage determination. Confronting real life data with DMP model.

Reference: Pissarides (2000) chapt. 1.

8 Alternative Approaches: Behavioral Macroeconomics and Post Keynesian Models

Departure from REH: limits to cognitive abilities, computations of models with heuristics, limits of arbitrage, fundamentalists vs. chartists, applications in foreign exchange markets. Post Keynesian & stock-flow consistent models: computation of solution path in high-dimensional models.

Readings: Grauwe (2012) chapt. 1, *Shleifer and Vishny (1997), *Chiarella, He, and Zheng (2013), Blecker (2002).

References and Further Readings

- Adda, Jérôme and Russell Cooper (2003). *Dynamic Economics*. Cambridge, Massachusetts: MIT Press.
- Aiyagiri, S. Rao (1994). "Uninsured Insurance Risk and Aggregate Saving". In: *The Quarterly Journal of Economics* 109.3, pp. 659–684.
- Bilbiie, Florin O. (2008). "Limited asset markets participation, monetary policy and (inverted) aggregate demand logic". In: *Journal of Economic Theory* 140.1, pp. 162–196.
- Blecker, Robert (2002). "Distribution, Demand and Growth in Neo-Kaleckian Macro-Models". In: *The Economics of Demand-Led Growth*. Edward Elgar Publishing. Chap. 8, pp. 129–152.
- Brock, William and Leonard Mirman (1972). "Optimal economic growth and uncertainty: The discounted case". In: *Journal of Economic Theory* 4.3, pp. 479–513.
- Chiarella, Carl, Xue-Zhong He, and Min Zheng (2013). "Heterogeneous expectations and exchange rate dynamics". In: *The European Journal of Finance* 19.5, pp. 392–419.

- Cooley, Thomas F., ed. (1995). *Frontiers of Business Cycles Research*. Princeton University Press.
- Galí, Jordi (2008). *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New-Keynesian Framework*. Princeton: Princeton University Press.
- Grauwe, Paul de (2012). *Lectures on Behavioral Macroeconomics*. Princeton University Press.
- Heer, Burkhard and Alfred Maußner (2008). *Dynamic General Equilibrium Modeling: Computational Methods and Applications*. Heidelberg: Springer Berlin.
- Judd, Kenneth L. (2023). *Numerical Methods in Economics*. 2nd ed. The MIT Press.
- King, Robert G. and Sergio T. Rebelo (1999). "Resuscitating Real Business Cycles". In: *Handbook of Macroeconomics*. Ed. by J.B. Taylor and Michael Woodford. Vol. 1. Elsevier Science B.V.
- Krueger, Dirk, Fabrizio Perri, Luigi Pistaferri, and Giovanni L. Violante (2010). "Cross-sectional facts for macroeconomists". In: *Review of Economic Dynamics* 13.1. Special issue: Cross-Sectional Facts for Macroeconomists, pp. 1–14.
- Krusell, Per, Jr. Smith, and A. Anthony (1998). "Income and Wealth Heterogeneity in the Macroeconomy". In: *Journal of Political Economy* 106.5, pp. 867–896.
- Kydland, Finn E. and Edward C. Prescott (1982). "Time to Build and Aggregate Fluctuations". In: *Econometrica* 50.6, pp. 1345–1370.
- (1996). "The Computational Experiment: An Econometric Tool". In: *The Journal of Economic Perspectives*, pp. 69–85.
- Ljungqvist, Lars and Thomas J. Sargent (2012). *Recursive Macroeconomic Theory*. third. Cambridge, Massachusetts: MIT Press.
- Lucas, Robert E. (1980). "Methods and Problems in Business Cycle Theory". In: *Journal of Money, Credit and Banking* 12.4, pp. 696–715.
- McCandless, George (2008). *The ABCs of RBCs: An introduction to dynamic macroeconomic models*. Cambridge, Massachusetts: Harvard University Press.
- Novalés, Alfonso, Esther Fernández, and Jesús Ruiz (2014). *Computational Economics*. Routledge.
- Pissarides, Christopher A. (2000). *Equilibrium Unemployment Theory*. 2nd. MA: MIT Press.
- Shleifer, Andrei and Robert W. Vishny (1997). "The limits of arbitrage". In: *The Journal of Finance* 52.1, pp. 35–55.
- Smets, Frank and Raf Wouters (2003). "An estimated dynamic stochastic general equilibrium model of the euro area". In: *Journal of the European Economic Association* 1.5, pp. 1123–1175.
- Stachurski, John (2009). *Economic Dynamics: Theory and Computation*. MIT Press.
- Summers, Lawrence H. (1990). "Some Skeptical Observations on Real Business Cycle Theory". In: *Federal Reserve Bank of Minneapolis Quarterly Review*.
- Uribe, Martín and Stephanie Schmitt-Grohé (2017). *Open Economy Macroeconomics*. Princeton University Press.