Computational Macroeconomics

(Optional Course, 4 credits)

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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

Most of the course will rely on *Python* as the main programming language. Initial lectures will show you how to install and set up Python on your computer and use *JupyterLab* to write codes in it. The students will also get familiar with *Julia*, which can be used in the same *JupyterLab* environment. In addition, the course will also cover some basics of *MATLAB*; however, being a proprietary (and expensive) software, this can be accessed only in some machines in the Computer Lab. The macroeconomic models will be typically developed in the class using one of these languages. The students will mostly 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.

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: 50%, Project: 50%.

Course Outline*

1 The Computational Experiment

A big picture of what we cover in this course, and why do we do this.
Reference: Kydland and Prescott (1996).

2 Programming Basics using 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, 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

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.

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).

*Starred readings are optional

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

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Grauwe, Paul de (2012). *Lectures on Behavioral Macroeconomics*. Princeton University Press.

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Uribe, Martín and Stephanie Schmitt-Grohé (2017). *Open Economy Macroeconomics*. Princeton University Press.