Macroeconomic Models: Theory to Code

Syllabus

Instructor: Alessandro T. Villa

alessandrotenzinvilla.com | alessandro.tenzin.villa@gmail.com

TA: Will Pennington (wpennington@frbchi.org)

Overview

This short module takes you from economic theory to working code for dynamic macro models. We move from deterministic growth to stochastic RBC, and finally to a New Keynesian RBC with Rotemberg nominal rigidities solved by projection.

Meetings & Support

- **Lectures:** *Tuesdays* at 3:30 PM, (10/7, 10/14, 10/21)
- **Discussion Section:** *Fridays*, 3:00-4:00 PM (flexible). Organized by the TA (Will Pennington). Students work independently from Tuesday to Friday, then can receive help in the discussion section.

Evaluation & Code Policy

- **No grades.** It is entirely up to you how much effort to put in.
- **Solutions:** Clean and commented code that solves the homeworks will be distributed at the *beginning of the next class*. The solution will be available in this *GitHub* repository.
- **Programming language:** You may use any language (MATLAB, Julia, Python, etc.). Official solutions will be provided in **MATLAB**.

Learning Objectives

By the end, you should have some experience with:

- Deriving equilibrium conditions and steady states from microfoundations.
- Formulating recursive problems and identifying state and control variables.
- Implementing **Value Function Iteration** and **Projection** combined with **Policy Function Iteration**.

- Simulating Markov chains and model paths using approximated policies.
- Interpreting impulse responses and policy functions economically.

Class Outline

Class I: The Neoclassical Investment Model and Value Function Iteration (VFI)

- Deterministic neoclassical growth with inelastic labor and risk-neutrality.
- Bellman equation, VFI, and extracting policy functions.
- **Exercise:** Solve for the steady state and use Value Function Iteration to compute the **dynamic investment policy** and the transition to the steady state.

Economic insight: In a frictionless, risk-neutral world, firms face no reason to smooth investment. They instantly jump to the efficient capital stock because every unit invested yields the same certain return. With no uncertainty or curvature, the economy leaps directly to its steady state—**subject only to the natural resource constraint that consumption cannot become negative**. In this simple frictionless general equilibrium environment, investment is limited only by the aggregate resources available in the economy.

Lecture Slides: Class I Slides (PDF)
Homework Guide: Homework I Guide (PDF). (Try from scratch, or use the guide for help :-)

Class II: Real Business Cycle (RBC), Risk Aversion, Elastic Labor Supply

- Stochastic TFP (two-state Markov), CRRA preferences, and disutility of labor.
- Competitive equilibrium $\Leftrightarrow$ planner; recursive formulation.
- Value function iteration with expectations and an intratemporal labor FOC.
- **Exercise:** Solve the stochastic RBC with elastic labor and simulate policies and paths.

Economic insight: Once shareholders are risk averse, they care about consumption smoothing. Investing too aggressively would mean sacrificing dividends today, so identical firms accumulate capital gradually. Dynamics arise because agents value a smoother consumption path rather than instant efficiency.

Lecture Slides: Class II Slides (PDF)
Homework Guide: Homework II Guide (PDF). (Try from scratch, or use the guide for help :-)

Class III: Nominal Rigidities, Technology Shocks, and Projection

- Introduce nominal rigidities through Rotemberg adjustment costs and a Taylor rule for monetary policy.
- Represent the equilibrium as a system of N functional nonlinear equations in N unknown policy functions.
- Solve this system using **projection and time iteration (or policy function iteration)**.
- Simulate Markov TFP shocks to generate model paths, impulse responses, and interpret the dynamics.
- **Exercise:** Implement projection, compute equilibrium residuals at collocation nodes, iterate to convergence, and simulate the model.

Economic insight: A positive productivity shock lowers firms' marginal costs, reducing the pressure to raise prices. Because nominal rigidities slow adjustment, inflation falls even as output and real wages rise. The result is a smooth, disinflationary expansion—the hallmark of a supply-driven boom.

Lecture Slides: Class III Slides (PDF)
Homework Guide: Homework III Guide (PDF). (Try from scratch, or use the guide for help :-)

Weekly Rhythm

1. **Tuesday (Class):** Theory → equations → algorithm → coding guidance.
2. **Tue – Fri:** Independent work (any language).
3. **Friday (Discussion):** Hands-on help with Will.
4. **Next Tuesday (Start of Class):** Distribution of a clean, commented **MATLAB** solution for the previous class.

References

- Ljungqvist & Sargent (2023), *Recursive Macroeconomic Theory.*
- Miranda & Fackler (2002), *Applied Computational Economics and Finance.*
- Heer & Maussner (2024), *Dynamic General Equilibrium Modeling.*

Note: Colored text (e.g., slides, GitHub links) in this document is clickable.