A Very Short Introduction to Computational Methods in Macro

Frantisek Masek, Sapienza University of Rome

frantisek.masek@uniroma1.it

Course description

The course aims to briefly introduce key numerical and computational tools and methods used in solution techniques of macro models nowadays. We start with a recap of perturbation approximation and extend it for the case of an occasionally binding constraint (e.g. an effective lower bound). Nevertheless, the main part of the course is devoted to global solution techniques. Specifically, we solve macro models using spectral methods (Chebyshev polynomials) and finite element methods or deploying dynamic programming methods as value function iteration.

Even though I try to introduce at least some theoretical concepts that I consider to be necessary along with the course content, the main purpose of the course is to show you various codes and help you to solve various models on your own. We go from a simple first-order perturbation solution of RBC and the three equation NK models through models embedding an occasionally binding constraint solved by extended perturbation solutions or projection methods. You also solve canonical heterogeneous agent models of the Bewley-Hugget-Aiyagari kind. Time permitting, we solve even Krusell-Smith heterogeneous agent model with aggregate uncertainty. Hence, we cover all the legacy that current Heterogeneous Agent New Keynesian (HANK) models are based on. The course is taught in Matlab.

Course textbooks

Miranda, Mario J. and Fackler, Paul L. *Applied Computational Economics and Finance*

Heer, Burkhard and Maussner, Alfred. *Dynamic General Equilibrium Modeling: Computational Methods and Applications*

Ljungqvist, Lars and Sargent, Thomas J. *Recursive Macroeconomic Theory*

Course content

Local solution methods

Perturbation techniques and how to deal with occasionally binding constraints in a local approximation A quick recap of the perturbation solution and outline of other local approximation options that can be used when a conventional linear approximation around a certain point cannot be used (e.g. due to the presence of occasionally binding constraint - thus, non-differentiability). Those could be the piecewise-linear perturbation of Guerrieri and Iacoviello (2015), the new shocks method of Holden (2019), or the two-state Markov process in the way of Eggertson et al. (2021) establish it. Primarily showing everything using the basic three equation NK model. Potentially I can show some stuff also within the Smets-Wouters-like medium scale model.

Global solution techniques

Intro to reinforcement learning and dynamic programming A fast route around prerequisites necessary to know for recursive macro (Bellman equation, contraction mapping theorem, Blackwell's sufficient condition, etc.). Solving deterministic problems by value function iteration using the Ramsey–Cass–Koopmans growth model. Extension for aggregate uncertainty to solve the Stochastic Growth Model by VFI. Possible improvements of VFI and a quick outline of the policy function iteration.

Intro to the projection methods Concepts of interpolation, splines, and collocation method. Chebyshev projection approximation shown using the simple RBC model or Lucas Asset-Prinicng model (using the simplest possible models to be focused only on the method itself). Finite elements approach using splines applied on the simple three equation NK model with the ZLB. For all this stuff, I use mostly the CompEcon toolbox from Miranda and Fackler to make it more comprehensive for everyone. However, in case of simple models I can show also some *from the scratch* code.

Heterogeneous agents and incomplete markets models Showing how to use some of the aforementioned tools to solve incomplete markets models of Huggett (1993) and Aiyagari (1994). If there's time, intro to the problem of adding aggregate uncertainty to these simple heterogeneous agent models. Thus, how to cope with idiosyncratic and aggregate uncertainty at once (problem with time-varying wealth distribution as a high-dimensional state variable and approximate aggregation as the solution used in Krusell-Smith (1998)).

Quantum leap to current HANK models Showing that this strand of macro literature going back to Aiyagari and others is today's cornerstone of what is called HANK models. Only theoretically introducing how NK strand and Bewley-Hugget-Aiyagari HA strand ended up emerging into HANK. Maybe just mentioning some numerical procedures that are used to solve quantitative HANK models (depending upon time).