Computational Methods in Economics – Course Outline

This course provides a five lectures introduction to numerical methods in economics, and in particular to its applications in macroeconomics. The course is intended for students that are economically mature (with at the least a Master's degree), but computationally inexperienced (although a superficial familiarity with Matlab is required). The course is targeted to *users* of numerical methods rather than *developers* of such methods. As a consequence, a strong emphasis will be put on "what works" with relatively little theoretical justifications. A very large share of these lectures comes from my experience as both a user and as a developer of numerical methods, rather than from some explicit references. However, Kenneth Judd's book "Numerical Methods in Economics" provides an excellent – although somewhat theoretical – treatment of these topics.

The course includes 5 problem sets with the associated codes. The correct code will be made available to the students after the course. The outline of the lectures and problem sets are provided below.

1. **An introduction to Dynamic Programming.** The first lecture will first recap the ideas underlying recursively and Bellman's principle of optimality, both in the deterministic and stochastic case. Subsequently we will discuss how to implement these ideas using value function iteration together with some elementary computational methods. As a final part, we will find a computationally convenient way of retrieving the unconditional distribution of the endogenous variables (which can be used to calculate business cycle statistics, for instance).

   Exercise: Solve the stochastic Ramsey growth model using value function iteration. Simulate the model, and calculate the unconditional distribution.

2. **Functional Approximation and nonlinear equations.** The second lecture will focus on functional approximations and solving nonlinear equations. The first part will discuss various interpolation methods such as linear interpolants, cubic splines, as well as orthogonal polynomial, and discuss their merits. The second part with illustrate various ways of solving nonlinear equations, such Newton's method and bisection.

   Exercise: Illustrate the central limit theorem computationally; solve a nonlinear equation using Newton's methods; and solve a (nonlinear) functional equation.

3. **Solving nonlinear rational expectations models.** Using the tools learnt in the second lecture, the third lecture will revisit some of the ideas introduced in lecture one. More specifi-

cally, we will use our knowledge about functional approximations in conjunction with nonlinear equation solvers in order to solve nonlinear rational expectations models highly efficiently (i.e. faster and more accurately than the methods illustrate in the first lecture). We discuss methods such as fixed point iteration, time iteration, and the method of endogenous gridpoints. Lastly, we will take a look at methods dealing with occasionally binding constraints – such as borrowing, or collateral, constraints – and consider further developments in deriving the unconditional distribution of endogenous variables.

   Exercise: Solve the stochastic Ramsey growth model with irreversible investment using the tools developed in the lecture.

4. **Incomplete markets models.** The fourth lecture will develop the tools needed to solve incomplete markets models (or, equivalently, heterogenous agent models). As we will see, deriving the unconditional distribution of endogenous variables will be imperative to find an equilibrium. We will discuss the Hugget model, the Aiyagari model, and the Krusell and Smith model.

   Exercise: Solve for the equilibrium of an Aiyagari model. Calculate the transitional dynamics.

5. **Continuous Time Models and Methods.** The fifth and final lecture will introduce method to solve models in continuous-, as opposed to discrete-, time. These methods have recently undergone a renaissance as they have some very useful computational advantages. In particular, they have been recently used to solve rich Incomplete Market Models with nominal rigidities and aggregate shocks to better our understanding of monetary policy (e.g. HANK models).

   Exercise: Solve the Diamond-Mortensen-Pissarides model with a finite EIS.

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