Intro to Empirical Methods in Macroeconomics

Syllabus

Basic Information

- **Schedule**: Jan 7 - Jan 11.
- **Contact Information**: Pablo A. Guerron Quintana, Office: , Email: guerron@bc.edu
- **Office Hours**: by appointment only.

Course Description

In this course, we will learn methods to solve and estimate nonlinear dynamic general equilibrium models (DSGE). Although the target audience is macro/international economics students, the class will be taught in a very general form so students from other fields may find beneficial to take the course. The material is mostly based on lecture notes jointly developed with Jesus Fernandez-Villaverde (U. Penn). They will be available before each class.

In the first part of the course, the student will be introduced to tools in software engineering and numerical analysis. The second part of the course is devoted to global methods to solve DSGE models. Some of these methods may be familiar to you because of economic examples in other Ph.D. courses. We will go into the details of why these methods work and how to apply them to a variety of situations.

In the final part, you will be introduced to techniques to estimate models displaying nonlinear dynamics. Most of this part will concentrate on the particle filter and estimation using likelihood-based methods.

Because of its nature, this course is highly applied. It means that you will have to spend a lot of time implementing algorithms and learning new software. This is error/trial so keep doing it! By this point, you should be proficient in matlab (or gauss or octave). If you don't know a lower level language such as Fortran or C/C++, it is a great moment to start doing so. My recommendation is to go for C because it will open a world of possibilities. Fortran is a good option but is falling behind. I can tell you this because I know Fortran and C!

From time to time, I will distribute Julia, Matlab and C/C++/CUDA code. It will be a **very intense class** but if you are up to the challenge, I will try to go over using Graphical Processing Units (GPUs) and CUDA to solve some of the problems at hand.

Topics

Some Preliminaries

In this section, the student will be introduced to selected topics in software engineering and numerical methods needed in the second and third parts of the class. For this part, we will rely heavily on the lecture notes with Jesus Fernandez.

- Intro to high-performance computing.
- Optimization: derivative, non-derivative, simulation based.
- Numerical differentiation and integration (Judd, 1998), (Robert and Casella, 2005),(Judd, Maliar, and Maliar, 2016)
- Parallel programming: OpenMP, MPI, GPU–CUDA/Thrust, OpenACC.

Solving Nonlinear Models

The student will be exposed to methods to solve models that cannot be solved with traditional linearization methods. Examples of such cases are models with occasionally binding constraints (zero lower bound, non-negative investment, collateral constraints), default models, models with time varying risk. In addition, you will be exposed to a formal exposition of dynamic programming, which is a critical tool to work on models of search and matching or default.

- Value function iteration (Judd, 1998), (Sargent and Ljungqvist, 2018), (Heer and Maussner, 2009).
- Perturbation methods, pruning, generalized impulse responses (Schmidtt-Grohe and Uribe, 2016), (Judd, 1998), (Koop, Pesaran, and Potter, 1996), (Andreasen, Fernandez-Villaverde, and Rubio-Ramirez, 2016).
- Projection Methods (Judd, 1998), (Heer and Maussner, 2009), (Fernandez-Villaverde, Rubio-Ramirez, and Schorfheide, 2016), (Maliar and Maliar, 2015).

Estimation of Nonlinear Models

Now that you know how to solve nonlinear models, we turn the issue of how we take these models to the data.

- Refresher Kalman filtering.
- Extended and Unscented Kalman filtering.
- Particle filtering (Herbst and Schorfheide, 2016), (Doucet, Freitas, and Gordon, 2001), (Fernandez-Villaverde, Guerron-Quintana, and Rubio-Ramirez, 2015c).

- Other filtering approaches: Partial information filtering; Simulated method of moments and particle filtering.
- Metropolis Hasting meets Particle Filter (Herbst and Schorfheide, 2016), (Fernandez-Villaverde et al., 2015c), (Fernandez-Villaverde et al., 2016), (Fernandez-Villaverde and Rubio-Ramirez, 2007), (Robert and Casella, 2005).
- Applications: stochastic volatility — interest rate and fiscal uncertainty, time-varying parameters — good luck or good policy, smooth transition AR — productivity in Detroit, zero lower bound (Fernandez-Villaverde, Guerron-Quintana, Kuester, and Rubio-Ramirez, 2015b), (Fernandez-Villaverde, Guerron-Quintana, Rubio-Ramirez, and Uribe, 2011), (Herbst and Schorfheide, 2016), (Fernandez-Villaverde et al., 2015c), (Fernandez-Villaverde, Gordon, Guerron-Quintana, and Rubio-Ramirez, 2015a), (van Dijk, Terasvirta., and Franses, 2002)

References

M. Andreasen, J. Fernandez-Villaverde, and J. Rubio-Ramirez. The pruned state-space system for non-linear models: Theory and empirical applications. Working paper, Emory University, 2016.

A. Doucet, N. Freitas, and N. Gordon. Sequential monte carlo methods in practice. Springer, 2001.

J. Fernandez-Villaverde and J. Rubio-Ramirez. Estimating macroeconomic models: A likelihood approach. *Review of Economic Studies*, 74:1059–1087, 2007.

J. Fernandez-Villaverde, P. Guerron-Quintana, J. Rubio-Ramirez, and M. Uribe. Risk matters: The real effects of volatility shocks. *American Economic Review*, 101(6):2530–2561, 2011.

J. Fernandez-Villaverde, G. Gordon, P. Guerron-Quintana, and J. Rubio-Ramirez. Nonlinear adventures ad the zero lower bound. *Journal of Economic Dynamics and Control*, 57:182–204, 2015a.

J. Fernandez-Villaverde, P. Guerron-Quintana, K. Kuester, and J. Rubio-Ramirez. Fiscal volatility shocks and economic activity. *American Economic Review*, 105(11):3352–84, 2015b.

J. Fernandez-Villaverde, P. Guerron-Quintana, and J. Rubio-Ramirez. Estimating dynamic equilibrium models with stochastic volatility. *Journal of Econometrics*, 185:216–229, 2015c.

J. Fernandez-Villaverde, J. Rubio-Ramirez, and F. Schorfheide. Solutions and estimation for dsge models. Handbook of macroeconomics vol. 2, 2016.

B. Heer and A. Maussner. Dynamic general equilibrium modeling. Springer, 2009.

E. Herbst and F. Schorfheide. Stochastic volatility. Princeton university press, 2016.

K. Judd. Numerical methods in economics. Mit press, 1998.

K. Judd, L. Maliar, and S. Maliar. How to solve dynamic stochastic models computing expectations just once. *Quantitative Economics*, forthcoming:1–47, 2016.

G. Koop, H. Pesaran, and S. Potter. Impulse response analysis in non-linear models. *Journal of Econometrics*, 74(1):119–147, 1996.

L. Maliar and S. Maliar. Merging simulation and projection approaches to solve high-dimensional problems with an application to a new keynesian model. *Quantitative Economics*, 6:1–47, 2015.

C. Robert and G. Casella. Monte carlo statistical methods. Springer, 2005.

T. Sargent and L. Ljungqvist. Recursive macroeconomic theory. Fourth edition 2018, MIT Press, 2018.

S. Schmidtt-Grohe and M. Uribe. Open economy macroeconomics. Textbook, Columbia University, 2016.

N. Stokey and R. Lucas. Recursive methods in economic dynamics. Harvard university press, 1999.

D. van Dijk, T. Terasvirta., and P. Franses. Smooth Transtion Autoregresive Models — A Survey of Recent Developments. *Econometric Reviews*, 21(1):1–47, 2002.