Introduction to Dynamic Stochastic General Equilibrium models using Dynare: Simulations and Sensitivity Analysis

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25-26 July 2017

Introduction

In recent years Dynamic Stochastic General Equilibrium (DSGE) models have moved from academic circles and are now playing an important role in the formulation and communication of monetary policy of the majority of Central Banks worldwide.

DSGE models are built on microeconomic foundations and on economic agent's intertemporal optimization behaviour. In DSGE models future uncertain outcomes depends on current agents choices and, crucially, current macroeconomics outcomes are influenced by agent's expectations about the future (*dynamic* and *stochastic* dimensions). The *general equilibrium* dimension highlights the interaction between economic agents and policymakers.

While traditional macroeconometric forecasting models are vulnerable to the Lucas critique,[1] the role of expectations makes DSGE model not subject to such a critique and makes them a natural benchmark for evaluating the welfare effects of policy changes.

The aim of this course is to provide an hands-on approach to simulation and sensitivity analysis of DSGE models using the free software Dynare. Dynare offers a user-friendly and intuitive way of describing these models. It is able to perform simulations of the model given a calibration of the model parameters and is also able to estimate these parameters given a dataset.

[1] They fail to recognize that optimal decision rules of economic agents vary systematically with changes in policy.

References:

- Clarida, R., Galí, J. and Gertler, M. (1999). "The Science of Monetary Policy: A New Keynesian Perspective". Journal of Economic Literature 37 (4): 1661-1707.
- Galí, J. (2015): *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications*, Princeton University Press.
- Kydland, F.E. and Prescott, E.C. (1982). "Time to Build and Aggregate Fluctuations". Econometrica 50 (6): 1345-1370.
- Lucas, R.E. Jr. (1976). "Econometric Policy Evaluation: A Critique". Carnegie-Rochester Conference Series on Public Policy 1: 19-46.
- Rotemberg, J. and Woodford, M. (1997). "An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy". NBER Macroeconomics Annual 12: 297346.

Prerequisites

This is an intermediate course mainly aimed at researchers or practitioners in Macroeconomics. Participants should have basic knowledge of macroeconomics, simple DSGE models[2] and taylor series expansion, log-linearization and dynamic optimization at Master or 1^{st} year-PhD level. Basic knowledge of Matlab or Octave programming is necessary while prior knowledge of Dynare programming is not necessary but will constitute an advantage.

This will be an interactive course so student are encouraged to come with their laptop if possible. They should have either Matlab or Octave installed as well as the latest Dynare version 4.5.0 that they can download for free at www.dynare.org.

[2]The standard Real Business Cycle and New Keynesian models as presented, for example, in chapter 1 of Cooley and Nason and chapters 2 and 3 of Galí (2015).

Course outline

The course is taught in 4 sessions of 1.5 hours each. The material will be self-contained.

Lecture 1: Introduction to Dynare with applications to the One Sector Growth Model.

This lecture will present a self-contained introduction to Dynare programming tools. We will discuss the structure of a .mod file and introduce Macro-processing language options. Using the one sector growth model as a starting example we will discuss how to simulate models log-linearized by the researcher or how to let dynare linearize their non-linear equilibrium conditions instead. We will review the main options available for deterministic and stochastic simulations and identify and analyze the outputs produced by Dynare.

Readings:

- Dynare. *Manual*.
  download here
- Mancini Griffoli, T. (2013). *Dynare User Guide*.
  download here
- Pfeifer, J (2013). *An Introduction to Graphs in Dynare*.
  download here

Lecture 2: Advanced simulation tools in Dynare with applications to the Real Business Cycle model

Using a standard Real Business Cycle (RBC) model we will show how to compute and calibrate the steady state externally using matlab scripts and demonstrate how to perform higher order approximations. We will then discuss various extensions of the standard RBC model.

Readings:

- Cooley, T. (2009). *Frontiers of Business Cycle Research*, Princeton University Press. Chapter 1.
- Hansen, G. (1985)."Indivisible Labor and the Business Cycle", *Journal of Monetary Economics*, 16, 309-327.

- Dennis, R. (2009). "Consumption Habits in a New Keynesian Business Cycle Model", *Journal of Money Credit and Banking*, 41 (5), 1015-1030.

- Greenwood, J., Hercowitz, Z. and Krusell, P. (2000). "The role of investment-specific technological change in the business cycle," *European Economic Review*, 44(1), 91-115.

Lecture 3: Stability and Indeterminacy of DSGE models with applications to the New Keynesian Model and Credit Constraints

This lecture will introduce the New Keynesian (NK) model of the business cycle and extend it to allow for hand-to-mouth (credit-constraint) consumers. These models will be used to show how to perform stability and indeterminacy analysis of DSGE models using Dynare.

Readings:

- Galí, J. (2015): *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications*, Princeton University Press.

- Galí, J., López-Salido, D., Vallés, J. (2004). "Rule-of-Thumb Consumers and the Design of Interest Rate Rules", *Journal of Money Credit and Banking*, 36 (4), 739-763.

Lecture 4: Global Sensitivity Analysis with applications to the response of Hours to Technology shocks in DSGE models.

Finally, this lecture will introduce the students to the Global Sensitivity Analysis toolbox developed by Ratto (2008). RBC and NK models with CES production function as in Cantore et al. (2014) will be used to demonstrate the prior sensitivity analysis features of this toolbox.

Readings:

- Cantore C., Ferroni F., León-Ledesma, M. (2017). "The Dynamics of hours worked and technology", *Journal of Economic Dynamics and Control*, 82, 67-82.

- Cantore, C., León-Ledesma, M., McAdam, P., Willman,A. (2014). "Shocking Stuff: Technology Hours and Factor Substitution", *Journal of the European Economic Association*, 12 (1), 108-128.

- Ratto, M.. (2008). "Analysing DSGE Models with Global Sensitivity Analysis", *Computational Economics* 31 (2):115-139.