The Science and Art of DSGE Modelling:
A Dynare-Based Course on Model Construction,
Calibration, Estimation and Policy Analysis

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April 29, 2013
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1 Introduction

The Centre for International Macroeconomic Studies (CIMS) in the School of Economics will hold a 5-day summer course, 9th - 13th September 2013, on the construction and estimation of Dynamic Stochastic General Equilibrium (DSGE) macroeconomic models, and their use for policy analysis. The material will cover the underlying theory proceeding in steps from the Real Business Cycle Model through to a medium-sized New Keynesian Model. It will also cover the theoretical basis for Bayesian Estimation and Computational Methods. This is a hands-on course based on available facilities in the software platform Dynare. Model software will be provided, consisting of models set-up in Dynare in a manner suitable for simulation, calibration, estimation and policy analysis.

The course will be delivered in two parts. Part I which will be on the 9th and 10th September will concentrate on the basic construction of DSGE models and the estimation of the linearized New Keynesian Model in a Dynare environment. It is designed for those without any experience of setting up DSGE models in Dynare. Part II which will be from 11th - 13th September will focus on intermediate and advanced topics. Participants who have attended previous courses given by CIMS, or are experienced DSGE modellers and users of Dynare, will be able to enrol for only Part II.

The fees for academics and PhD students are: £300 for Part I and £400 for Part II and we are offering a special rate of £600 for the five days. For participants from central banks, ministries or the private sector the fees are £600 for Part I and £800 for Part II. (£1200 for the five days). Lunch, coffee, course notes and model software is included in this cost.

Taken over the five days the participants will be guided through a seamless methodology for the construction, solution, estimation and use for forecasting and policy analysis of DSGE models. The methodology can be summarized by the following steps:

1. The construction of a DSGE model describing the first-order conditions for economic agents in the form of a set of non-linear difference equations
2. The solution of the steady state to be used for both solution and calibration
3. Bayesian estimation methods
4. Model comparisons between different models or variants of same model
5. Model validation by comparison with second moments and a benchmark DSGE-VAR
6. Forecasting
7. Optimal policy analysis
8. The rational expectations solution and estimation under imperfect information

We will show that the main features of New Keynesian (NK) Dynamic Stochastic General Equilibrium (DSGE) models consist of a ‘Real Business Cycle’ (RBC) core, with an outer shell that includes nominal rigidities and other frictions. We will then discuss how to take the NK model to the data, focusing on empirical implementations based on Bayesian system estimation methods. The Course will demonstrate the use of the model for forecasting and optimal monetary policy exercises. Sessions will include an in-depth treatment of computations methods used to solve DSGE models and a particular emphasis will be placed on information assumptions made by rational agents.

This is a hands-on course based for the most part on existing facilities in the software platform Dynare (see Adjemian et al. (2011) and other useful documentation available on their website www.dynare.org). The mornings will be devoted to lectures and in the afternoons students will attend a tutorial session in a computer laboratory.

2 Instructors

The instructors for the course are Dr Cristiano Cantore, Dr. Filippo Ferroni, Dr Vasco Gabriel, Professor Paul Levine, Dr Antonio Mele, Professor Joseph Pearlman and Dr Bo Yang. All have considerable experience in both teaching and researching in the area of DSGE modeling.

Cristiano Cantore is a Senior Lecturer in the School of Economics at the University of Surrey. He graduated from the Bocconi University (Milan, Italy) in 2004. He then completed his MSc degree in Economics at Pompeu Fabra University (Barcelona, Spain). In 2006, he started the PhD in Economics at University of Kent where he was awarded an ESRC Scholarship. Cristiano’s PhD focussed on financial frictions and capital labour substitution in dynamic stochastic general equilibrium (DSGE) models. Cristiano has also
worked at the OECD and at the ECB as a trainee and visited the Bank of Spain in 2012 as a research fellow. In September 2009 he was appointed as full time Lecturer and in 2013 he was promoted to Senior Lecturer at the University of Surrey. His research fields mainly include macroeconomic theory, computational economics, monetary economics and production theory.

**Filippo Ferroni** completed his undergraduate degree in Economics at Bocconi University in Milan in 2003. Subsequently, he undertook postgraduate studies in Economics at Universitat Pompeu Fabra in Barcelona where received the Master of Science in Economics in 2005 and the PhD in Economics in 2009. Since September 2009, he has worked as an economist at Banque de France, first in the macroeconomic forecasting directorate and then in the monetary policy directorate. He has teaching experience in econometrics and quantitative methods from serving as lecturer and teaching assistant at IESEG School of Management and at SciencePo in Paris. His interest ranges from empirical macroeconomics, quantitative methods and applied times series analysis.

**Vasco Gabriel** graduated in Economics from the Technical University of Lisbon in 1995, where he was awarded the ICEP prize. He received a masters degree in Econometrics in 1998 from the same institution. In 2002, he completed his PhD in Economics at Birkbeck College, University of London. He taught at the University of Minho, Portugal, before being appointed as a Lecturer at the University of Surrey in 2004 and Senior Lecturer in 2010. Vasco’s main field of specialization is Macroeconometrics, focusing on the application of non-linear methods, as well as general inference issues in macro models. He has published extensively in these areas including publications in Economic Letters, the Journal of Macroeconomics, the Journal of Money, Credit and Banking and the Oxford Handbook of the Indian Economy.

**Paul Levine** received a first-class BSc and a PhD, both in Mathematics, from the University of Manchester and an MSc in economics (distinction) at Queen Mary. In 1984 he became a senior research officer at the Centre for Economic Forecasting, London Business School and was appointed Professor of Economics at the University of Leicester in 1989. In 1994 he moved to the University of Surrey where he now leads the Centre for International Macroeconomic Studies (CIMS). He has acted as a consultant and/or visiting researcher at the IMF, the ECB, the National Institute of Public Finance and Policy in New Delhi and
the central banks of Nigeria and Pakistan. His main research activity is in constructing empirically-based DSGE models for the purpose of macroeconomic policy analysis. Other research interests are Growth Theory, Labour Migration, Defence Economics and Conflict, and the Economics of Regulation. He has published over 100 refereed articles or chapters and 2 books in these areas.

**Antonio Mele** is a Lecturer in the School of Economics at the University of Surrey. He graduated from the Bocconi University (Milan, Italy) in 2001. He then completed his DEA in Econometrics and Economic Theory at Université de Toulouse 1 in 2003, then he went to Universitat Pompeu Fabra (Barcelona, Spain) obtaining a MSc in Economics in 2004 and the PhD in Economics in 2009. Before joining University of Surrey, he was a Postdoctoral Research Fellow at Nuffield College at University of Oxford (2009-2012), where he taught a course in Computational Macroeconomics. His research fields are dynamic contracts, macroeconomic theory, computational economics, monetary economics and learning.

**Professor Joseph Pearlman** graduated from Cambridge University with a BA Mathematics (2nd Class) in 1972, and then an MSc (distinction) in 1974 followed by a PhD in Control Theory in 1977, both from Imperial College. He later completed a part-time MSc in Economics from LSE in 1986. He had ESRC funding for a sabbatical at the Centre for Economic Forecasting at London Business School 1988-89. He is currently a Professor of Economics in the Economics Department at City University. His general Research Interests are: Macroeconomic Policy; Growth Theory; International Trade and Growth. He has had articles published in the European Economic Review, Economic Journal, Journal of Economic Dynamics and Control, Journal of Economic Theory, Oxford Economic Papers, and the Journal of Development Economics.

**Bo Yang** is a Lecturer at Xi’an Jiaotong - Liverpool University (XJTU), Suzhou, China and a part-time Research Officer in the School of Economics at the University of Surrey. He graduated from the University of Hull in 2003 and completed his MSc degree in Financial Economics with a Distinction at Queen Mary, University of London. Following the completion of his PhD at the University of Surrey on the topic of DSGE modeling in 2008, Bo was appointed, by Surrey and London Metropolitan University, as a research officer to support the research activities of the EU-funded project “MONFISPOL”. His research fields include macro-econometrics, monetary economics, Bayesian econometrics
and computational economics, focusing on the applications and quantitative analysis of DSGE models. He has published in the Review of International Economics, the Oxford Handbook of the Indian Economy and he has a forthcoming publication in the Economic Journal.

3 Course Outline

3.1 Preliminary Reading and Basic requirements

Preliminary material will be circulated to participants a few weeks before the Course. We expect students to read Gali (2008) chapters 1-3 before the course. As the course is software based we expect students to be familiar with the basics of Matlab and Dynare. Documentation to familiarize with Matlab is available on the Mathworks website and summarized below. We do not expect students to be familiar with advanced programming techniques in Matlab but a basic knowledge of matrix and array operations, graphics and programming skills is required to understand the material of the course.

1. Getting Started with Matlab documentation.
   
   http://www.mathworks.co.uk/help/techdoc/learn_matlab/bqr_2pl.html

2. A short video presenting the basics of Matlab.

   http://www.mathworks.co.uk/videos/matlab/getting-started-with-matlab.html

3. A long presentation with more details about operations, presenting plots and programming. (Requires registration and login; It is not required go through everything that is presented here for the course).

   http://www.mathworks.co.uk/webex/recordings/NA_110719_introml/index.html


5. Dynare Quick Start.

   http://www.dynare.org/documentation-and-support/quick-start

6. Dynare Example codes.

   http://www.dynare.org/documentation-and-support/examples
3.2 Programme of Lectures and Lab Sessions

- **Day 1: Basics I** (Cristano Cantore, Paul Levine)
  - Introduction
  - Dynare, Matlab Basics
  - RBC Model with zero growth steady state
  - Dynare Set-up without separate steady state
  - The New Keynesian (NK) Model
  - Linearization
  - Stability-Indeterminacy
  - Exercises in Lab.

- **Day 2: Basics II** (Vasco Gabriel, Bo Yang)
  - Bayesian Estimation of Linearized NK Model (with no capital)
    * Preparing the Data including use of various filters
    * An Introduction to Bayesian Methodology
    * Estimation of Linearized Models
    * Model Comparisons by Likelihood Races
  - Comparison of Second Moments of Model with Data
  - Variance and Historical Decomposition
  - Exercises in Lab.

- **Day 3** (Cristano Cantore, Filippo Ferroni, Vasco Gabriel, Joe Pearman, Bo Yang)
  - Use of the External Steady State
  - Calibration with an External Steady State
  - A Balanced-Non-Zero-Growth Steady State of the NK Model (with capital)
  - Bayesian Methodology
  - Identification
  - Data-Consistent Estimation of the Non-Linear NK Model (with capital)
– DSGE-VAR Estimated Model
– Use of Estimated NK Model for Forecasting
– Exercises in Lab.

• **Day 4** (Paul Levine, Joseph Pearlman)
  – Optimal Monetary Policy
    * The Ramsey Problem
    * Optimal Time-Consistent Policy
    * Optimized Simple Rules
    * Zero Lower Bound Considerations
    * Robust Optimized Rules
  – Solution and Estimation under Perfect and Imperfect Information
  – Exercises in Lab.

• **Day 5** (Paul Levine, Joe Pearlman, Antonio Mele)
  – Solution with Occasionally Binding Constraints
  – Computational Methods
    * Perturbation Methods
    * Dynamic Programming Non-local Methods
  – Exercises in Lab.

### 3.3 Reading

There are a number of excellent books on modern dynamic macroeconomics that provide background reading for the course. Dejong and Dave (2007) covers many of the empirical aspects of DSGE modelling. This should be supplemented with Del Negro et al. (2007) and Del Negro and Schorfheide (2004). To understand the models themselves a good recent text-book to start with is Wickens (2012). Then go on to Gali (2008).

At some stage researchers will need to dip into three seminal books: one on New Keynesian models, Woodford (2003) and the other two covering the empirical side, Geweke (2005) and Canova (2007); but they are all challenging reads!

3.4 General Software

The course is based on the following software:

1. Dynare and Matlab programs (to be handed out after the Course).
2. Matlab with the optimization toolbox
3. The latest Dynare (Currently 4.3)

Users would also find Winedt or Lyx useful as part of the output from Dynare is in the form of Latex files.

References


