

**Methods for Applied Macroeconomic Research**  
**BSSM, July 2006**  
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**Outline**

The course present a self contained exposition of methods needed to conduct empirical analyses with dynamic stochastic general equilibrium models. The course will cover:

- a) Numerical methods for the solution of DSGE models
- b) Calibration techniques
- c) Structural estimation: GMM, simulation estimators and maximum likelihood
- d) Introduction to Bayesian estimation.

It is assumed that participants are familiar with:

- Current models used in dynamic macroeconomics, monetary economics, international and finance and
- Matlab (and/or RATS) programming languages.

Lectures are based on chapters 2, 5, 6, 7 and 9 of my forthcoming book: *Methods for Applied Macroeconomic Research*, Princeton University Press. Copies of the chapters are posted on my homepage ([www.econ.upf.edu/crei/people/canova](http://www.econ.upf.edu/crei/people/canova) under published work).

Given time constraints, practice sessions will be limited to illustrating codes which implement some of the techniques discussed in the lectures. Codes will be freely distributed to participants and will be posted on the school page. Since there will be only a limited number of computers available for the participants who want to practice on their own, attendees are encouraged to bring their own laptops and/or try the programs independently, possibly before the sessions.

**Program**

Starred articles will be discussed in some details during the course.

1) **Solution of DSGE models (1 lecture)**

- Dynamic Programming and Lagrange Multipliers
- Linearization methods
- Second order methods

**References**

- Cooley, T. (1995) (ed.) *Frontiers of Business Cycle Research*, Princeton University Press.
- Marimon and Scott (1999) (eds.) *Computational Methods for the Study of Dynamic Economies*, Oxford University Press.

- King, R., Plosser, C. and Rebelo, S. (1988), Appendix to "Production, Growth and Business Cycle: I The Basic Neoclassical models", University of Rochester, working paper
- Klein, P. (2000) "Using the generalized Schur form to solve a multivariate linear rational expectations model", *Journal of Economic Dynamics and Control*, 24, 1405-1423.
- (\*) Uhlig, H. (1999) A methods for Analyzing Nonlinear Dynamic Stochastic Models Easily in Marimon, R. and Scott A. (eds.) *Computational Methods for the Study of Dynamic Economies*, Oxford University Press.
- (\*) Schmitt-Grohe, S. and Uribe, M. (2004) "Solving Dynamic General Equilibrium Models using Second Order Approximation to the Policy function", *Journal of Economic Dynamics and Control*, 28, 755-775

## 2) Calibration techniques (1 lecture)

- Basic calibration approach
- Model evaluation in calibrated models

### References

- (\*) Canova, F. and Ortega, E. (2000) "Testing Calibrated General Equilibrium Models", in Mariano, R., T. Shuermann and M. Weeks (eds.) *Inference using Simulation Techniques*, Cambridge University Press.
- Canova, F., (1994), "Statistical Inference in Calibrated Models", *Journal of Applied Econometrics*, 9, s123-s144.
- DeJong, D., Ingram, B. and Whiteman, C., (1996), "Beyond Calibration", *Journal of Business and Economic Statistics*, 14, 1-10.
- Diebold, F., Ohanian, L. and Berkowitz, J., (1998), "Dynamics General Equilibrium Economies: A Framework for Comparing Models and Data", *Review of Economic Studies*, 68, 433-451.
- Gregory, A. and Smith, G., (1990), "Calibration as Estimation", *Econometrics Reviews*, 9, 57-89.
- (\*) Gregory, A. and Smith, G., (1991), "Calibration as Testing: Inference in Simulated Macroeconomic Models", *Journal of Business and Economic Statistics*, 9, 297-303.
- (\*) Watson, M., (1993), "Measures of Fit for Calibrated Models", *Journal of Political Economy*, 101, 1011-1041.

### 3) GMM and simulation estimators (1 lecture)

- GMM and GIV in linear and nonlinear models
- Simulation estimators and matching impulse responses
- Application to DSGE models

#### References

- Hamilton, J., (1994), *Time Series Analysis*, Princeton University Press.
- Hayashi, F., (2002), *Econometrics*, Princeton University Press.
- Hansen, L.P., (1982), "Large Sample Properties of GMM Estimators", *Econometrica*, 50, 1029-1054.
- Hansen, L.P. and Singleton, K., (1982), "Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models", *Econometrica*, 50, 1269-1286. (corrigenda, 1984).
- Newey, W. and West, K., (1987), "A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix", *Econometrica*, 55, 703-708.
- (\*) Lee, B. and Ingram, B., (1991), "Simulation Estimation of Time Series Models", *Journal of Econometrics*, 47, 197-205.
- Duffie, D. and Singleton, K., (1993), "Simulated Moments Estimation of Markov Models of Asset Prices", *Econometrica*, 61, 929-952.
- Gourieroux, C. and Monfort, A. (1995) "Testing, Encompassing and Simulating Dynamic Econometric Models", *Econometric Theory*, 11, 195-228.
- Christiano, L., Eichenbaum, M. and Evans, C. (2005) "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy, *Journal of Political Economy*
- (\*) Canova, F. and Sala, L. (2005) Back to square one: identification issues in DSGE models, ECB working paper.

### 4) Maximum likelihood estimation (1 lecture)

- State space models and Kalman filter
- Prediction error decomposition and numerical tips
- Application to DSGE models

### References

- Hamilton, J. (1994), *Time Series Models*, Princeton University Press.
- Altug, S. (1989), "Time to build and Aggregate Fluctuations: Some New Evidence", *International Economic Review*, 30, 883-920.
- (\*) Kim, J. (2000) Constructing and Estimating a realistic Optimizing Model of Monetary Policy, *Journal of Monetary Economics*, 45, 329-359
- Ireland, P. (2000) Sticky Price Models and the Business Cycle: Specification and Stability, *Journal of Monetary Economics*, 47, 3-18.
- (\*) Ireland, P. (2004) A method for taking Models to the data, *Journal of Economic Dynamics and Control*, 28, 1205-1226.
- Ireland, P. (2001) "Technology Shocks and the Business Cycle: An Empirical Investigation", *Journal of Economic Dynamics and Control*, 703-719.
- (\*) Kurmann, A. (2003) ML estimation of Dynamic Stochastic Theories with an Application to New Keynesian Pricing, University of Quebec at Montreal.
- Linde', J. (2005), "Estimating New Keynesian Phillips curve: A Full Information maximum likelihood", *Journal of Monetary Economics*.

### 5) Introduction to Bayesian Methods (1 lecture)

- Preliminaries : Bayes Theorem, Prior Selection, Nuisance Parameters
- Posterior simulators
- Application to DSGE models

### References

- Gelman, A., J. B. Carlin, H.S. Stern and D.B. Rubin (1995), *Bayesian Data Analysis*, Chapman and Hall, London.
- Zellner, A. (1971) Introduction to Bayesian Inference in Econometrics, Wiley and Sons.
- (\*) Canova, F. and Pappa, E. (2003) Price Differential in Monetary Union: the role of fiscal shocks, forthcoming *Economic Journal*.
- Casella, G. and George, E. (1992) Explaining the Gibbs Sampler *American Statistician*, 46, 167-174.
- Chib, S. and Greenberg, E. (1995) Understanding the Hasting-Metropolis Algorithm, *The American Statistician*, 49, 327-335.

- Tierney, L (1994) Markov Chains for Exploring Posterior Distributions (with discussion), *Annals of Statistics*, 22, 1701-1762.
- (\*) Del Negro, M. and F. Schorfheide (2004), " Priors from General Equilibrium Models for VARs", *International economic Review*, 45, 643-673.
- Ingram, B. and Whitemann, C. (1994), "Supplanting the Minnesota prior. Forecasting macro-economic time series using real business cycle priors, *Journal of Monetary Economics*, 34, 497-510.
- (\*) Schorfheide, F. and Ahn, S (2005), "Bayesian Analysis of DSGE Models", forthcoming, *Economic Reviews*.
- Smets, F. and R. Wouters (2003) An Estimated Stochastic DSGE model of the Euro Area, *Journal of the European Economic Association*1, 1123-1175.
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- Del Negro, M, Schorfheide, F., Smets, F. and Wouters, R (2005) "On the fit and forecasting performance of New-Keynesian Models", manuscript.
- Adolfson, M, Laseen, S., Linde, J. and Villani, M. (2005) "Bayesian Estimation of an Open Economy DSGE model with Incomplete pass-through", Riksbank manuscript.