Econ 226
Bayesian and Numerical Methods
James D. Hamilton, UCSD
Spring 2015

SCHEDULE

Class meets Mondays and Wednesdays 8:00 - 9:20 a.m., Monday March 30 - Wednesday June 3 in Econ 200
No class Monday May 25
Office hours: Mondays 9:30 - 10:30 a.m. in Econ 307 and by appointment (jhamilton@ucsd.edu)

GRADES

Grades for the course will be determined as follows:

40% in-class midterm exam 8:00 - 9:20 a.m. Wednesday, April 29
60% paper proposal due 8:00 a.m. Wednesday June 3

The paper proposal should be typed (double-spaced, 12-point font, 1.5 inches space on right margin). The idea is to propose a project, but not actually perform any data collection or estimation. The proposal should consist of two sections. The first briefly describes some of the related literature with a clear description of one or more previous papers and a statement of the relation or model you would propose to estimate. You do not need to propose an original model, but it should be something that has not been estimated with Bayesian methods or for which you would add something missing from previous Bayesian analysis of that model. The second section should provide a detailed description of the methods and algorithm you would use to perform Bayesian estimation of the model. Note that this second section must be self-contained-- you should not assume that the reader is familiar with the algorithms or Bayesian approach, and you will be graded based on how clearly and accurately you explain them here.

BOOKS

Many of the readings can be found in the following three books:

Greenberg: Edward Greenberg, *Introduction to Bayesian Econometrics*, Cambridge University Press, Second edition, 2012.

TSA: James D. Hamilton, *Time Series Analysis*, Princeton University Press, 1994.

SSM: Chang-Jin Kim and Charles R. Nelson, *State-Space Models with Regime Switching*, MIT Press, 1999.

In addition, copies of the slides used in some of the lectures will periodically be linked from the course web page (check for last-minute updates before class) at:

http://econweb.ucsd.edu/~jhamilto/Econ226.html

COURSE OUTLINE

I. Bayesian econometrics

A. Introduction
Thomas S. Ferguson (1967), *Mathematical Stastistics: A Decision Theoretic Approach*, Academic Press, Sections 1.1-1.5
Greenberg, Chapter 2
TSA, Section 12.1
Morris H. DeGroot (1970), *Optimal Statistical Decisions*, McGraw-Hill, Sections 9.1-9.6

B. Bayesian inference in the univariate regression model
SSM, Sections 7.1 and 7.2
TSA, Section 12.2
Greenberg, Chapter 4

C. Statistical decision theory
Thomas S. Ferguson (1967), *Mathematical Stastistics: A Decision Theoretic Approach*, Academic Press, Sections 1.6-1.8 and 2.1-2.8
Greenberg, Chapter 3
Mark J. Schervish (1995), *Theory of Statistics*, Chapter 3, Springer-Verlag.

D. Large-sample results
Tony Lancaster (2004), *An Introduction to Modern Bayesian Econometrics*, Chapter 1, Blackwell.
Mark J. Schervish (1995), *Theory of Statistics*, Section 7.4, Springer-Verlag.

E. Diffuse priors

Mark J. Schervish (1995), *Theory of Statistics*, pp. 121-123, Springer-Verlag.

DeGroot, Morris H. (1970), *Optimal Statistical Decisions*, Chapter 10, McGraw-Hill.

F. Numerical Bayesian methods

Greenberg, Chapters 5-8

Christian P. Robert and George Casella (2004), *Monte Carlo Statistical Methods*, Second edition, Section 2.3, Chapter 7, Section 9.1, Chapter 12.

A.F.M. Smith and A.E. Gelfand (1992), "Bayesian Statistics without Tears: A Sampling-Resampling Perspective," *American Statistician* vol. 46, pp. 84-88.

SSM, Sections 7.3 and 7.4

Siddhartha Chib and Edward Greenberg (1996), "Markov Chain Monte Carlo Simulation Methods in Econometrics," *Econometric Theory* 12, pp. 409-431.

John Geweke (1992), "Evaluating the Accuracy of Sampling-Based Approaches to the calculation of Posterior Moments," in *Bayesian Statistics* 4, pp. 169-193, edited by J.M. Bernardo, J.O. Berger, A.P. Dawid, and A.F.M. Smith, Oxford University Press. Working paper version.

Siddhartha Chib (1995), "Marginal Likelihood from the Gibbs Output," *Journal of the American Statistical Association*, 90, pp. 1313-1321.

II. Vector autoregressions

A. Introduction

TSA, Section 11.6, pp. 324-336

B. Normal-Wishart priors for VARs

K. Rao Kadiyala and S. Karlsson (1997) "Numerical Methods for Estimation and Inference in Bayesian VAR-models," *Journal of Applied Econometrics* vol. 12, pp. 99-132.

John Geweke (1988), "Antithetic Acceleration of Monte Carlo Integration in Bayesian Inference," *Journal of Econometrics* vol. 38, pp. 73-89.

C. Bayesian analysis of structural VARs

Christopher A. Sims and Tao Zha (1998) "Bayesian Methods for Dynamic Multivariate Models," *International Economic Review* vol. 39, pp. 949-968.

D. Identification using inequality constraints

Jonas E. Arias, Juan F. Rubio-Ramirez, and Daniel F. Waggoner (2013), "Inference Based on SVARs Identified with Sign and Zero Restrictions: Theory and Applications," working paper, Duke University.

Christiane Baumeister and James D. Hamilton (2014), "Sign Restrictions, Structural Vector Autoregressions, and Useful Prior Information," working paper, UCSD.

E. Integrating VARs with dynamic general equilibrium models

Marco del Negro and Frank Schorfheide (2004), "Priors from General Equilibrium Models for VARS," *International Economic Review* 45, pp. 643-673. F. Selecting priors for DSGEs

Marco del Negro and Frank Schorfheide (2008), "Forming Priors for DSGE Models (and How It Affects the Assessment of Nominal Rigidities)", *Journal of Monetary Economics,* 55, no. 7, pp. 1191-1208.

III. Linear state-space models.

A. State-space representation of a dynamic system

TSA, Section 13.1.

B. Kalman filter

TSA, Section 13.2

Mark W. Watson and Robert F. Engle (1983), "Alternative Algorithms for the Estimation of Dynamic Factor, MIMIC and Varying Coefficient Regression Models," *Journal of Econometrics* 23, pp. 385-400.

C. Using the Kalman filter

TSA, Sections 13.3-13.6

Maximo Camacho and Gabriel Perez-Quiros (2010), "Introducing the Euro-Sting: Short Term Indicator of Euro Area Growth," *Journal of Applied Econometrics,* 25(4), pp. 663–694.

D. Bayesian analysis of linear state-space models

SSM, Chapter 8

E. Solutions to linear rational expectations models

Olivier Jean Blanchard and Charles M. Kahn (1980), "The Solution of Linear Difference Models under Rational Expectations," *Econometrica* 48, pp. 1305-1317.

Robert G. King and Mark W. Watson (1998), "The Solution of Singular Linear Difference Systems under Rational Expectations," *International Economic Review* 39, pp. 1015-1026.

Paul Klein (2000), "Using the Generalized Schur Form to Solve a Multivariate Linear Rational Expectations Model," *Journal of Economic Dynamics and Control*, 24, pp. 1405-1423.

Christopher Sims (2001), "Solving Linear Rational Expectations Models," *Journal of Computational Economics*, 20(1-2), pp.1-20.

F. Using the Kalman filter to estimate dynamic stochastic general equilibrium models

Frank Smets and Raf Wouters (2003), "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area," *Journal of the European Economic Association* 1, pp. 1123-1175.

Jean-Philippe Laforte (2007), "Pricing Models: A Bayesian DSGE Approach for the US Economy," *Journal of Money, Credit and Banking*, 39, pp. 127-154.

Christopher Otrok (2001), "On Measuring the Welfare Cost of Business Cycles," *Journal of Monetary Economics* 47, pp. 61-92.

Frank Smets and Raf Wouters (2005), "Comparing Shocks and Frictions in USW and Euro Area Business Cycles: A Bayesian DSGE Approach," *Journal of Applied Econometrics* 20, pp. 161-183.

Marco del Negro, Frank Schorfheide, Frank Smets, and Rafael Wouters (2007), "On the Fite of New Keynesian Models," *Journal of Business and Economic Statistics* pp. 123-143.

IV. Markov-switching models

A. Introduction to Markov-switching models
TSA, Chapter 22

B. Economic theory and changes in regime
James D. Hamilton (2014), "Macroeconomic Regimes and Regime Shifts," working paper, UCSD.

C. Bayesian analysis of Markov-switching models
SSM, Chapter 9
Filardo, Andrew J., and Stephen F. Gordon (1998), "Business Cycle Durations," *Journal of Econometrics*, 85, pp. 99-123

D. State-space models with Markov switching.
SSM, Chapter 10

V. Nonlinear state-space models

A. Extended Kalman filter
James D. Hamilton (1994), "State-space models," in *Handbook of Econometrics*, Vol. 4, pp. 3039-3080, edited by Robert F. Engle and Daniel L. McFadden, Amsterdam: North-Holland.

C. Particle filter
Drew Creal (2012), "A Survey of Sequential Monte Carlo Methods for Economics and Finance," *Econometric Reviews*, 31(3), pp. 245-296.
Michael K. Pitt and Neil Shephard (1999), "Filtering via simulation: auxiliary particle filters," *Journal of the American Statistical Association*, 94, pp. 590-599.
Thomas Flury and Neil Shephard (2011), "Bayesian Inference Based Only on Simulated Likelihood: Particle Filter Analysis of Dynamic Economic Models," *Econometric Theory* 27, pp. 933-956

D. Solution and estimation of nonlinear DSGE

Jesús Fernández-Villaverde and Juan F. Rubio-Ramírez (2007), "Estimating Macroeconomic Models: A Likelihood Approach," *Review of Economic Studies*, 74(4), pp. 1059-1087.

Christopher Gust, David Lopez-Salido, and Matthew E. Smith (2013), "The Empirical Implications of the Interest-Rate Lower Bound," working paper, Federal Reserve Board.

VI. Time-varying variances

A. Overview

TSA, Chapter 21

Hamilton, James D. (2009), "Macroeconomics and ARCH," in *Festschrift in Honor of Robert F. Engle*, pp. 79-96, edited by Tim Bollerslev, Jeffry R. Russell and Mark Watson, Oxford University Press. Working paper version.

B. Extensions

TSA, Chapter 21

Torben G. Andersen, Timothy Bollerslev, and Francis X. Diebold (2002), "Parametric and Nonparametric Volatility Measurement," in *Handbook of Financial Econometrics*, edited by Yacine Aït-Sahalia and Lars P. Hansen, Amsterdam, North Holland. Working paper version.

Robert Engle (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models," *Journal of Business & Economic Statistics* 20(3), pp. 339-350.

C. Markov-switching GARCH

Hamilton, James D., and Raul Susmel (1994), "Autoregressive Conditional Heteroskedasticity and Changes in Regime," *Journal of Econometrics* 64, 307-333.

Gray, Stephen F. (1996), "Modeling the Conditional Distribution of Interest Rates as a Regime-Switching Process," *Journal of Financial Economics* 42, 27-62.

Haas, Markus, Stefan Mittnik, and Marc Paolella (2004), "A New Approach to Markov-Switching GARCH Models," *Journal of Financial Econometrics* 2, 493-530.

D. Stochastic volatility

Kim, Sangjoon, Neil Shepherd, and Siddhartha Chib (1998), "Stochastic Volatility: Likelihood Inference and Comparison with ARCH Models," *Review of Economic Studies*, 65, 361-393

Siddhartha Chib, Federico Nardari and Neil Shephard (2002), "Markov Chain Monte Carlo Methods for Stochastic Volatility Models", *Journal of Econometrics*, 108, 281-316

VII. Model selection

Greenberg, Sections 3.2.4 and 7.1.2.

Schwarz, Gideon (1978), "Estimating the Dimension of a Model," *Annals of Statistics* 6, 461-464.

Cavanaugh, Joseph E., and Andrew A. Neath (1999), "Generalizing the Derivation of the Schwarz Information Criterion," *Communications in Statistics: Theory and Methods*, 28, 49-66.