Outline for
A Course in Bayesian Econometrics

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Overview

This is a course in the theory and practice of Bayesian econometrics . The course will be divided in two. The first part (approximately 6 lecture hours) will be based on my textbook, Koop (2003), and introduce the basic ideas and tools of Bayesian econometrics. It will cover Bayesian theory, Bayesian analysis of the linear regression model and extensions of the regression model. These models are important in their own right, but also offer a convenient framework for learning about posterior simulation. Modern Bayesian econometrics relies heavily on computational algorithms and, hence, part of the course will be focussed on posterior simulation. Different posterior simulators such as Monte Carlo integration, Gibbs sampling and Markov Chain Monte Carlo (MCMC) will be introduced. The second part of the course (approximately 6 lecture hours) will consider some macroeconomic applications. It will begin with a survey of Bayesian approaches to univariate time series analysis including state space models. Finally, we will discuss extensions of these which are popular in the recent macroeconomic literature (i.e. models with regime-switching or structural breaks and time varying VARs). These extensions will be discussed through textbook material and research papers.

Reading List

My lectures will be based on my textbooks and research papers (the latter being available at http://personal.strath.ac.uk/gary.koop/):

Koop, G. (2003). *Bayesian Econometrics*, published by Wiley.

Koop, G., Poirier, D. and Tobias, J. (2007). *Bayesian Econometric Methods*, Cambridge University Press, (Volume 7 in the *Econometrics Exercises* Series edited by Karim Abadir, Jan Magnus and P.C.B Phillips)

The second book, Koop, Poirier and Tobias (2007), is composed of theoretical and computational exercises which contain solutions (Matlab code containing solutions to the computer problems is available on the book's website). By choosing appropriate questions, the reader can develop theoretical and/or computational skills in their area of particular interest. The computer sessions will involve some particular questions relating to the lecture material.

Other books for the reader interested in learning more about Bayesian econometrics include:

Lancaster, T. (2004). *An Introduction to Modern Bayesian Econometrics*, published by Blackwell.

Poirier, D. (1995). *Intermediate Statistics and Econometrics: A Comparative Approach*, published by The MIT Press.

Bauwens, L., Lubrano, M. and Richard, J.-F. (1999). *Bayesian Inference in Dynamic Econometric Models*, published by Oxford University Press.

Geweke, J. (2005). *Contemporary Bayesian Econometrics and Statistics*, published by Wiley.

Prerequisites

The course will assume that participants have a basic knowledge of probability (i.e. definitions and rules relating to conditional, marginal and joint probabilities and definitions and properties of common distributions such as the multivariate Normal and t-distributions). In addition, the participant should have a knowledge of basic matrix algebra. The Appendices to Koop (2003) provide a summary of the probability theory and matrix algebra used in this course and the participant with an inadequate background in these topics should read these before the course begins.

Course Content

References to readings are from my textbook, *Bayesian Econometrics*, unless otherwise specified.

Topic 1: An Overview of Bayesian Econometrics.

Reading: Chapter 1.

Topic 2: The Normal Linear Regression Model with Conjugate Prior

Computational topic: Monte Carlo integration.

Reading: Chapters 2 and 3.

Topic 3: The Regression Model with General Error Covariance Matrices (including autocorrelation and the SUR model)

Computational topic: Gibbs sampling

Reading: pages 62-64 and Chapter 6.

Topic 4: Bayesian Model Averaging in Univariate Time Series Models

This is an empirical topic which illustrates many of the previous Bayesian methods for regression models and introduce Bayesian methods for autoregressive models. It will introduce the idea of Bayesian model averaging in the context of a research paper.

Reading: Chapter 11 and "Forecasting in Dynamic Factor Models using Bayesian Model Averaging" (*Econometrics Journal,* 2004, co-authored with Simon Potter).

Topic 5: Bayesian State Space Modeling

Reading: Chapter 8

Topic 6: Bayesian Analysis of Extensions of AR and VAR Models

Reading: This lecture will draw on parts of Koop, Poirier and Tobias (2007), chapters 17 and 18 and aspects of research papers with the following one being of particular relevance:

Primiceri. G. (2005). "Time varying structural vector autoregressions and monetary policy," *Review of Economic Studies.*

Assessment

The course outline for ECON6370 provides an overview of the assessment. As specified there, there are two components for the Bayesian part of the course: a journal article review and a computer exercise. Some additional details of these are provided here.

Review

For the journal article review, you must choose a Bayesian journal article and review it. The review should be a maximum of five (word processed) pages long. The main part of the review will be a summary of the chief arguments made in the article. You should also analyse and interpret the article. You can either choose one of the articles listed below or find one which relates to your own interests. If you do the latter, please check with me first to make sure the article is appropriate.

Fernandez, C., Ley, E. and Steel, M. (2001). "Model uncertainty in cross-country growth regressions," *Journal of Applied Econometrics*, 16, 563-576.

Kim, C., Nelson, C. and Piger. J. (2004) "The less volatile U.S. economy: A Bayesian investigation of timing, breadth, and potential explanations," *Journal of Business and Economic Statistics,* 22, 80-93.

Poirier, D. (1988). "Frequentist and subjectivist perspectives on the problems of model building in economics," *Journal of Economic Perspectives*, 2, 121-144.

Primiceri. G. (2005). "Time varying structural vector autoregressions and monetary policy," *Review of Economic Studies.*

Sims, C and Uhlig, H. (1991). "Understanding unit rooters: A helicopter tour," *Econometrica,* 59, 1591-1600.

Sims, C. and Zha, T. (2006). "Were there regime switches in macroeconomic policy?" *American Economic Review*, 96, 54-81.

Computer Exercise

The second component of assessment is a computer exercise. The general idea is that you will be given a data set and model and are asked to describe methods for posterior simulation in this model, find, adapt or write code for doing posterior simulation and then present empirical results using your code. Beyond this general description, I am deliberately leaving details of the assessment flexible so that you can push the project in any direction you want. The project should be a maximum of five written pages plus up to two pages of tables/graphs presenting your empirical results. You should also hand in the computer code itself. You may choose one of the following two topics.

Topic 1. *Extensions of the Basic Threshold Autoregressive Model: Switches in the Error Variance*

In computer session 3, we went through several variants of the threshold autoregressive model using data on US GDP growth. In this project, you are asked to extend this model and carry out empirical work using inflation data (US quarterly data from 1953Q1 through 2006Q3, available on the web). You may wish to address questions such as "Is there evidence of threshold autoregressive behaviour?" and, if yes, "of which sort?". Researchers have been interested in whether the dynamics of inflation have been changing over time and one aspect of particular interest is whether its volatility is changing. This suggests we should extend the threshold autoregressive models of computer session 3 to allow for the error variance to change. Accordingly, in this project you should work with the following model:

$$\begin{array}{l} y_t = \beta_{10} + \beta_{11} y_{t-1} + ... + \beta_{1p} y_{t-p} + \sqrt{h_1^{-1}}\epsilon_t \text{ if } z_{t-d} \leq \tau \\ y_t = \beta_{20} + \beta_{21} y_{t-1} + ... + \beta_{2p} y_{t-p} + \sqrt{h_2^{-1}}\epsilon_t \text{ if } z_{t-d} > \tau \end{array},$$

where all definitions and assumptions are the same as in computer session 3 except that we now assume ϵ_t is i.i.d. $N(0,1)$. Note that any definition of z_{t-d} could be used (and you may wish to investigate more than one choice). However, it $z_{t-d} = t$ (i.e. it is simply time), then this model becomes one where the model's parameters change a time τ. This is called a structural break model and is commonly used in macroeconomic empirical work.

Note that, after doing computer session 3, you should have some MATLAB code for estimating closely related models. Furthermore, some basic code for this model is available through the website for *Bayesian Econometric Methods* (see Exercise 17.4 in particular). You may use and/or adapt and/or extend this code as you wish.

Topic 2. *Vector Autoregressive Modelling*

Macroeconomists often use VAR models involving a standard set of variables: the interest rate (this variable reflects policy choices) and the unemployment and inflation rates (two key variables of interest to policymakers but not directly under their control). In this project you are asked to do empirical work using a VAR for these variables (data is available in the file var.dat on the website). I am deliberately leaving details vague and you are free to use any prior you want, any (valid) way of doing Bayesian estimation and pushing the empirical work in any direction you want.

Note that, although *Bayesian Econometric Methods*, has some additional theoretical derivations for VAR models that might be of interest (see Exercise 17.6), it does not have Matlab code. So to do this project you will either have to create programs from scratch or obtain/adapt code from other sources. For instance, James Lesage's Econometrics Toolbox (see http://www.spatial-econometrics.com/) has Bayesian VAR code that you could download, study, figure out what it does and then use for the empirical work.