University of Pennsylvania **Economics 706, Spring 2008**

Econometrics II - Time Series Analysis

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Scheduled Class Time and Organization: Class will meet twice a week *Tuesdays and Thursdays from 9:00-10:30* for lecture in Room 309, McNeil. The teaching assistants will conduct a one hour discussion and review session once a week. Details will be announced.

Course Description:

The course provides an introduction to modern time series econometrics. We analyze deterministic trend models, autoregressive moving average (ARMA) models, vector autoregressions (VAR), and state space models. The analysis is mostly conducted in the time domain, however, the course includes a brief treatment of frequency domain approaches. We examine and illustrate various approaches to model estimation and inference, including least squares (LS), generalized method of moments (GMM), maximum likelihood (ML), and Bayesian methods. Applications are drawn from

macroeconomics, with focus on the empirical analysis of dynamic stochastic general equilibrium (DSGE) models and forecasting and policy analysis with structural vector autoregressions.

EVIEWS and Gauss will be used for computer-based calculations.

Prerequisites: Economics 705 or equivalent graduate level introduction to econometrics.

Course Web Page: Course documents and information are available via blackboard: *http://courseweb.library.upenn.edu*.

Course Requirements:

- **Problem Sets**: There will be approximately 8 problem sets, assigned during the semester. The problem sets are designed to give the students the opportunity to review and enhance the material learned in class. Students are encouraged to form small study groups, however, each student has to submit his or her own write-up of the solution. These solutions must be submitted on the specified due dates. [20%]
- **Midterm Exam**: Wednesday, March 25. [35%]
- **Final Exam / Prelim** : Friday, May 16. Counts both as Final and Metrics Prelim, Part II. [45%]

Course text:

There is no one textbook that exactly matches the material covered in class. I will make my lecture notes available on the internet. You should get a copy of Hayashi (2000), which covers the classical approach to time series analysis, except for spectral analysis. In addition I strongly recommend Geweke (2005), since it provides a solid introduction to Bayesian inference.

Hayashi, Fumio (2000): "*Econometrics,*" Princeton University Press, ISBN 0-691-01018-8, HB139.H39 2000.

Geweke, John (2005): *"Contemporary Bayesian Econometrics and Statistics,"* Wiley, New York, ISBN 0-471-67932-1.

Other textbooks that you might find helpful are (though I recommend that you take a close look before you purchase any of them):

General Econometrics:

Amemiya, T. (1985): "*Advanced Econometrics*," Harvard University Press.

Davidson, R. and J. MacKinnon (1993): "*Estimation and Inference in Econometrics*," Oxford University Press.

White, H. (1984): "*Asymptotic Theory for Econometricians*," Academic Press.

Time Series Analysis:

Brockwell, P.J. and R.A. Davis (1991): "*Time Series: Theory and Models*," Springer-Verlag.

Campbell, J.Y., A.W. Lo, and A.C. MacKinlay (1997): "*The Econometrics of Financial Markets*," Princeton University Press.

Granger, C.W.J. and P. Newbold (1987): "*Forecasting Economic Time Series*," Academic Press.

Hamilton, James D. (1994): "*Time Series Analysis*," Princeton University Press.

Harvey, A.C. (1990): "*The Econometric Analysis of Time Series*," MIT Press.

Modern Macroeconometrics:

Canova, Fabio (2007): *Methods for Applied Macroeconomic Research,* Princeton University Press.

DeJong, David and Chetan Dave (2007): *Structural Macroeconometrics,* Princeton University Press.

Bayesian Statistics and Econometrics:

Gelman, Andrew, John B. Carlin, Hal S. Stern, and Donald B. Rubin (1995): *"Bayesian Data Analysis,"* Chapman & Hall, New York.

Koop, Gary (2003): *"Bayesian Econometrics,"* John Wiley & Sons.

Lancaster, Tony (2004): *"An Introduction to Modern Bayesian Econometrics,"* Blackwell Publishing.

Poirier, Dale (1995): *"Intermediate Statistics and Econometrics - A Comparative Approach,"* MIT-Press.

Robert, Christian P. (1994): *"The Bayesian Choice,"* Springer-Verlag, New York,

Further references are provided in each section of the lecture notes.

Econometrics II – Course Outline

Note: The course outline is subject to change during the semester!

1 Deterministic Trend Model

Concepts: least squares estimation, asymptotic behavior of estimators, rates of convergence.

(i) Review: OLS Estimation of a Linear Regression Models

(ii) Analysis of the Deterministic Trend Model: Rates of Convergence, OLS Estimation and Serial Dependence

2 Asymptotic Theory for Dependent Processes

Concepts: large sample behavior of dependent processes.

(i) Empirical Measures of Dependency

(ii) Covariance Stationarity

(iii) Stationarity and Ergodicity

(iv) Martingales and Martingale Difference Sequences

3 Stationary ARMA Processes

Concepts: Lag operators, difference equations, maximum likelihood estimation.

(i) Theoretical Properties: Moving Average Processes

(ii) Theoretical Properties: Autoregressive Models

(iii) ARMA Models

(iv) Frequentist Maximum Likelihood Estimation of the Gaussian AR(p) Model

(v) Extensions to the Vector Case: VARs

4 Linear Rational Expectations (LRE) Models

(i) LRE models as approximations to dynamic stochastic equilibrium (DSGE) models.

(ii) Solving LRE models

(iii) Preview: Moment-based Estimation of linear and nonlinear rational expectations models

(iv) Preview: Likelihood-based Estimation of LRE models.

5 Extremum Estimation

(i) Generalized method of moments and maximum likelihood estimation interpreted as extremum estimation.

(ii) Consistency

(iii) Asymptotic Normality

(iv) Further Issues

6 Bayesian Analysis of Linear Time Series Models

Concepts: Bayesian inference, model selection, forecasting.

(i) Introduction to Bayesian Statistics: Point Estimation, Testing Theory

(ii) Bayesian Analysis of AR Models

(iii) Bayesian Model Selection: Determining the Order of an AR process

(iv) Markov-Chain Monte Carlo Methods to Generate Draws from Posteriors

7 State Space Models

(i) Bayesian Interpretation of the Kalman Filter

(ii) Computing likelihood functions for LRE models

(iii) Applications: LRE versus VAR models

8 Introduction to Spectral Analysis

Concepts: Fourier transformations, introduction to Kernel smoothing.

(i) Typical Spectrum of Macroeconomic Time Series

(ii) Spectral Representation for the Linear Cyclical Model

(iii) Spectral Representation for Stationary Processes

(iv) Filters

(v) Spectral Estimation

9 Analysis of Difference Stationary Time Series

Concepts: Frequentist unit root asymptotics.

(i) Autoregressive Models with a Unit Root

(ii) Testing for Unit Roots

(iii) Unit Roots from the Frequentist and the Bayesian Perspective

(iv) Cointegration and Error Correction Models