APPLIED TIME SERIES ANALYSIS
UPF Ph.D. Winter 2008

Professor: **Jesús Gonzalo**
(http://www.eco.uc3m.es/jgonzalo)
TA: **Ozan Eksi**

Description

Applied Time Series Analysis examines the models and statistical techniques used to study time series data in economics. A central message is that THEORETICAL time series analysis is useful because it helps us understand patterns in actual economic data, as well as CAUSAL relationships.

The course has two specific objectives. The first is to equip students with the tools necessary for state-of-the-art empirical research with economic time series data. This is designed for those students who are likely to use time series data in their Ph.D. theses (macro-economics, finance, marketing, accounting,...etc). The second objective is to lay out the econometric theory of time series analysis, with an emphasis on recent developments during the past 15-20 years.

The first block (part II) of the course presents the theory of univariate stationary and non-stationary time series variables. The second block (part III) focus on the multivariate level covering the different aspects of the VAR modelling that have been relevant in the recent macroeconomic time series literature. The last block (part IV) consists of some further topics that have become recently very popular in time series econometrics (some of these topics are excellent candidates to write a dissertation on).

Grading

The course work consists of a final exam, and a FIVE-page empirical project. This year will be focused on the "The Great Moderation" (see corresponding file on the web page). Grades for this course will be based on the final exam (70%), and the project (30%). The final exam will have two parts: Some questions (50%) and identification of 10 generated time series (20%).

Software

Econometrics and Time Series software: E-views, GAUSS, S-Plus, STATA, TSP, etc. I recommend the students to become familiar as soon as possible with at least two of the packages (E-views or STATA and Gauss or S-Plus). One menu-driven (good to analyze empirical data) and the other better designed for programming (good for simulations). This course will be heavily based on E-views.

COURSE OUTLINE

PART I: INTRODUCTION

1. BASIC CONCEPTS OF STOCHASTIC PROCESSES
   Definitions and examples of stochastic processes and time series. Stationarity and ergodicity. The mean. The autocovariance and autocorrelation function. One of the goals of time series analysis: Forecasts based on conditional expectation and Forecasts based on linear projection (least squares).

PART II: MODELS BASED ON UNIVARIATE INFORMATION

2. STATIONARY LINEAR MODELS I: CHARACTERIZATION AND PROPERTIES
   Wold's decomposition. Causal and Invertible ARMA processes. The Partial autocorrelation function. The Autocovariance generating function. Identification of ARMA processes.

3. STATIONARY LINEAR MODELS I': SPECTRAL ANALYSIS
   Spectral Densities. The Periodogram. Time-Invariant Linear Filters. The Spectral density of an ARMA process.

4. STATIONARY LINEAR MODELS II: ESTIMATION AND INFERENCE
   Least Squares Estimation. Asymptotic behavior of the sample mean and autocovariance function. Estimation of the Long-Run Variance. Inference on the parameters of ARMA models.
   Appendix: Asymptotics for linear processes (LLN and CLT). Martingale Theory.

5. MODEL SELECTION
   Box-Jenkins Methodology. Information Criteria: AIC, BIC, HQ and LCIC. Consistency of the IC. Inference on models selected by the IC. Testing versus IC.

6. FORECASTING
   Forecasts from ARMA and ARIMA models. The prediction function and its economic interpretation. Combination of forecasts. Evaluation of forecasts. Forecast comparisons of trend-stationary and unit root processes.

7. NON-STATIONARY LINEAR MODELS: THE CASE OF AN AR WITH A UNIT ROOT
   Deterministic trends versus stochastic trends. Processes with unit roots: Testing and Estimation. Decompositions in trend and cycle: Beveridge-Nelson decomposition and orthogonal decompositions.
   Appendix: The functional central limit theorem and the continuous mapping theorem.

8. NON-STATIONARY MODELS: THE CASE OF STRUCTURAL BREAKS
   Testing for a Single Break. Testing for Multiple Breaks. Unit Roots versus

Breaks.

PART III: MODELS BASED ON MULTIVARIATE INFORMATION

9. STATIONARY MULTIVARIATE LINEAR MODELS: VARs
Estimation and inference in VAR models. Exogeneity. Transfer functions derived from VAR models. Bivariate Granger causality tests. The impulse-response function. Variance decomposition. Standard errors for impulse-response functions. Structural VAR models: The Blanchard and Quah decomposition.

10. NON-STATIONARY MULTIVARIATE LINEAR MODELS I: VAR MODELS WITH UNIT ROOTS- COINTEGRATION
Spurious regression. Cointegration. Implications of cointegration for the VAR representation: the Error correction model (Granger's representation theorem). Testing for cointegration and estimation of the cointegrating vector: A single equation approach (OLS and DOLS). Testing for the rank of cointegration and estimation of the cointegrating vectors: A simultaneous equation approach (Reduced Rank Regression). Consequences of misspecification of the trend components on testing for cointegration.
Appendix: Asymptotic results for non-stationary vector processes. Canonical Correlations.

11. NON-STATIONARY MULTIVARIATE LINEAR MODELS II: VAR MODELS WITH UNIT ROOTS- COINTEGRATION
Common trends representations. Permanent and Transitory Decompositions: Stock-Watson and Gonzalo-Granger representations. Identification of the shocks of a cointegrated VAR: Gonzalo-Ng approach.

12. MODEL SELECTION
Consequences of lag or/and rank misspecification in VARs. Information criteria approach to select the number of lags and the rank of cointegration. Consistency of the IC; Testing versus IC.

PARTE IV: FURTHER TOPICS

13. LONG MEMORY
Definition. How long-memory appears in Economics. Modelling. Estimation and inference. Testing I(1) versus I(d). Testing I(d) versus I(0)+ Breaks.

14. THRESHOLD MODELS
Threshold autoregressive models. Conditions for Stationarity. Estimation, Inference and Model Identification. Testing linearity. The Case of Threshold Unit Root (TARUR and TARSUR Models).

15. DYNAMIC FACTOR MODELS
Standard Factor Models. Determination of the number of Factors. Inferential Theory for Factor Models.

TEXTBOOKS

The primary texts are **Brockwell and Davis** (1991), **Hamilton** (1994), and **Hayashi** (2000). The other texts provide treatments of various subtopics.

<u>Primary Texts</u>

Hamilton, J., *Time Series Analysis.* Princeton University Press, 1994.

Hayashi, F., *Econometrics.* Princeton University Press, 2000.

Brockwell, P.J. and R.A. Davis, *Time Series: Theory and Methods.* New York. Springer-Verlag, second edition 1991.

<u>Secondary Texts</u> (for particular topics)

Anderson, T., *The Statistical of Time Series.* Wiley, 1971.

Baltagi, B. editor of *A Companion to Theoretical Econometrics.* Blackwell, 2001.

Banerjee, A., J. Dolado, J.W. Galbraith, and D.F. Hendry, *Co-Integration, Error-Correction and the Econometric Analysis of Non-Stationary Data.* Oxford University Press, 1993.

Beran, J., *Statistics for Long-Memory Processes.* Chapman-Hall. 1994.

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Breiman, L., *Probability* (Classics in Applied Mathematics No. 7). SIAM. 1992.

Brockwell, P.J. and R.A. Davis, *Introduction to Time Series and Forecasting.* New York. Springer-Verlag, 1996.

Burnham, K. and D. Anderson, *Model Selection and Inference. A Practical Information-Theoretic Approach.* Springer 1998.

Campbell, J., Lo, A. and A. MacKinlay, *The Econometrics of Financial Markets.* Princeton. 1997.

Canova, F.,*Methods for Applied Macroeconomic Research.* Princeton, 2007.

Choi, B., *ARMA Model Identification.* Springer. 1992.

Clements, M.P. and D.F. Hendry, *Forecasting Economic Time Series.* Cambridge. 1998.

Cramer, H., and M.R. Leadbetter, *Stationary and Related Stochastic Processes.* Wiley, 1967.

Davidson, J., *Stochastic Limit Theory.* Oxford University Press, 1994.

Dejong, D., and Ch. Dave, *Structural Macroeconometrics.* Princeton, 2007.

Dhrymes, P.,*Time Series, Unit Roots, and Cointegration.* Academic Press, 1998.

Enders, W., *Applied Econometric Time Series.* John Wiley. 1995.

Fan, J., and Q. Yao, *Nonlinear Time Series.* Springer. 2003.

Fuller, W., *Introduction to Statistical Time Series.* John Wiley. 1995.

Gourieroux, C. and A. Monfort, *Time Series and Dynamic Models.* Cambridge, 1997.

Granger, C.W.J. and Newbold, P., *Forecasting Economic Time Series*, second edition. New York: Academic Press, 1986.

Granger, C.W.J. and Terasvirta, T, *Modelling Nonlinear Economic Relationships.* Oxford University Press, 1993.

Hansen, B., *Econometrics.* Manuscript at
http://www.ssc.wisc.edu/ bhansen/notes/notes.htm

Johansen, S., *Likelihood-Based Inference on Cointegrated VAR Models.* Oxford University Press, 1995.

Juselius, K., *The Cointegrated VAR Model.* Oxford University Press, 2006.

Li, Wai K.,*Diagnostic Checks in Time Series.* Chapman and Hall 2004.

Lutkepohl, H., *Inroduction to Multiple Time Series Analysis*, second edition. Springer Verlag, 1993.

Hall, P. and C.C. Heyde, *Martingale Limit Theory and Its Applications.* Academic Press. 1980.

G.S. Maddala and In-M. Kim, *Unit Roots, Cointegration, and Structural Change.* Cambridge. 1998.

Mikosch, T., *Elementary Stochastic Calculus.* World Scientific Publishing. 1998.

Mills, T., *The Econometric Modelling of Financial Time Series.* Cambridge University Press. 1997 (second edition).

Mills, T., and K. Patterson (editors), *Palgrave Handbook of Econometrics, vol 1. Econometric Theory.* Palgrave Macmillan. 2006.

Mittelhammer, R., *Mathematical Statistics for Economics and Business.* Springer Verlag, 1995.

Potscher, B.M. and I.R. Prucha, *Dynamic Nonlinear Econometric Models, Asymptotic Theory.* Springer Verlag. 1997.

Priestley, M.B., *Spectral Analysis and Time Series*, vols. 1 and 2 together. London: Academic Press, 1987.

Reinsel, G., *Elements of Multivariate Time Series Analysis.* Springer. 1993.

Robinson, P. (editor), *Time Series with Long Memory.* Oxford University Press, 2003.

Shiryayev, A.N. *Probability.* Springer. 1984.

Shumway, R.H. and D. Stoffer, *Time Series and Its Applications.* Springer. 2000.

Taniguchi, M., and Y. Kakizawa, M., *Asymptotic Theory of Statistical Inference for Time Series.* Springer, 2000.

Tong, H., *Non-Linear Time Series: A Dynamical System Approach.* Oxford. 1990.

Wei,W., *Time Series Analysis: Univariate and Multivariate Methods.* Addinson Wesley, 1990.

+ Lecture Notes and Papers

I hope you enjoy the course. GOOD LUCK