

**Economics 825**  
**Time Series Econometrics**  
**Spring 2007**

**Instructor:** Dr. Siyan Wang, PRN 316A, Tel: 831-1924, E-mail: [wangs@udel.edu](mailto:wangs@udel.edu)

**Lecture Times and Location:** TR 11:00am-12:15pm, PRN 231

**Office Hours:** TR 2:30-3:30pm or by appointment, PRN 316A

**Course Objectives**

The purpose of this course is to introduce the established theory and recent development in time series analysis. Because the field of time series econometrics is broad and still developing at a fast pace, this course focuses on a few subjects that have wide applications in macroeconomics and financial economics. While it provides a solid understanding of the underlining econometric theory, emphasis is placed on empirical applications.

In addition to the traditional techniques dealing with stationary univariate and multivariate time series models, the course also covers recent development in the areas of unit root tests, cointegration, modeling ‘volatility’, threshold regressions and Markov switching models.

**Texts**

(Required) Walter Enders (2003), *Applied Econometric Times Series*, 2<sup>nd</sup> edition, Wiley.  
ISBN: 0-471-23065-0            HB139.E55

(Required) James Hamilton (1994), *Time Series Analysis*, Princeton University Press.  
ISBN: 0-691-04289-6.            QA280.H264

(Optional) Ruey S. Tsay (2005), *Analysis of Financial Time Series*, 2<sup>nd</sup> edition, Wiley.  
ISBN: 0-471-69074-0            HA30.3T76

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

(Optional) Russell Davidson & James G. McKinnon (2004), *Econometric Theory and Methods*, Oxford University Press.  
ISBN: 0-19-512372-7            HB139.D3678

Depending on individual student's background and research interests, the following monographs may be useful during the course:

Jack Johnston and John DiNardo (1997), *Econometric Methods*, 4<sup>th</sup> edition, McGraw-Hill, New York.  
ISBN: 0-07-913121-2            HB139.J65

William H. Greene (2000), *Econometric Analysis*, Prentice Hall.  
ISBN: 0-13-013297-7            HB139.G74

R. F. Engle and C. W. J. Granger (1991), *Long-Run Economic Relationships: Readings in Cointegration*, Oxford University Press.  
ISBN: 0198283393            HB139.L66

Maddala, G.S. and In-Moo Kim (1998), *Unit Roots, Cointegration, and Structural Change*, New York: Cambridge University Press  
ISBN: 0-521-58257-1            HB139.M3555

Craig MacKinlay, Andrew W. Lo and John Y. Campbell (1997), *The Econometrics of Financial Markets*, Princeton University Press.  
ISBN: 0-619-04301-9            HG4523.C27

*Nonlinear Dynamics Chaos and Econometrics*, 1993, ed. M. Hashem Pesaran and Simon M. Potter, Wiley.  
ISBN: 0-471-93942-0            HB139.N66

### Computer Programs

Students are free to choose the software package when doing homework assignments. However, lab sessions make use of **Microfit for Windows**, version 4.1, and datasets for homework/lab exercises are available in Microfit tutorial or from the instructor. Advanced data manipulations, if needed, may be carried out using SAS. Those interested in programming may consider MATLAB as an alternative.

The following is a list of manuals/tutorials of some software packages.

Hanshem Pesaran and Baharam Pesaran, *Working with Microfit 4.0: Interactive Econometric Analysis*, 1997, Camfit Data LTD., available at  
<http://www.econ.cam.ac.uk/microfit/>

*SAS/ETS User's Guide, Version 8, Volumes 1 and 2*, SAS Institute.  
ISBN: 1-58025-489-6  
SAS on-line documentation is available at  
<http://www.udel.edu/topics/software/special/statmath/sasdoc/onldoc.htm>

Duane Hanselman and Bruce Littlefield, *Mastering Matlab 6: A Comprehensive Tutorial and Reference*, Prentice Hall, 2001.

ISBN: 0-13-019468-9      QA297.H293 2001

Econometrics toolbox in Matlab is available at

<http://www.spatial-econometrics.com/> and

<http://www.mathtools.net/MATLAB/index.html>

### Grading

1. Three homework assignments, 10% each, total 30%. Homework assignments are computer-based projects. For each assignment, students are required to submit a report presenting and interpreting the computer output.
2. One midterm exam, 30%. Midterm is given in-class, closed-notes, closed-book. Exam questions can be ‘analytical’ (e.g. solving problem sets) or ‘empirical’ (e.g. analyzing computer output).
3. Final project, 30%. Project requirements and data will be provided no later than May 1<sup>st</sup>. Project is due by 5:00pm on May 15<sup>th</sup>, the last day of class.
4. Presentation, 10%. Each student is required to present a published article in class. The article must be an empirical study that uses time series models and techniques discussed in this course. Presentation is tentatively scheduled on May 8<sup>th</sup> and 10<sup>th</sup>. A summary of the article must be submitted to the instructor two days before the presentation.

Analytical and computer exercises will be assigned but not graded. Answer keys will be provided.

**The faculty in the department of Economics are strongly committed to upholding the university policy on academic dishonesty. You are responsible for knowing and abiding by this policy. The policy is stated in the Code of Conduct section on academic dishonesty in the Official Student Handbook, and can be found online at**

**<http://www.udel.edu/stuhb/02-03/campuslife/policy1.html#code>**

**Violations will not be tolerated.**

## Course Outline

### Basics

1. Review of classic linear regression model
2. White noise process
3. Autocovariance, autocorrelation
4. Stability, stationarity, ergodicity
5. Brownian Motion

### Univariate Time Series Analysis --- Modeling the Conditional Mean

1. Stationary stochastic processes: Moving Average (MA) process, Autoregressive (AR) process, and mixed Autoregressive Moving Average (ARMA) process
2. Estimation and forecasting of ARMA model: exact and conditional ML estimator, deterministic and adaptive forecasts
3. Model selection and diagnostic checking: Wold decomposition theorem, Box-Jenkins model selection, Akaike's Information Criterion, Schwarz's Bayesian Criterion, Hannan-Quinn Criterion, DW statistic, Box-Pierce Q statistic, Ljung-Box Q statistic
4. Modeling seasonality
5. Nonstationary time series: models with deterministic trends, models with stochastic trends (unit roots), random walk process, Autoregressive Integrated Moving Average (ARIMA) process, Beveridge-Nelson decomposition theorem.
6. Testing for unit roots: Large sample theory of integrated variables, Dickey-Fuller tests, Augmented Dickey-Fuller tests, Phillips-Perron tests
7. DF-GLS test
8. Perron tests for unit root

### Applications:

1. Modeling and forecasting U.S. GNP using ARIMA model.  
Reference: Pesaran & Pesaran, chapter 11
2. Testing the random walk hypothesis of nominal exchange rate.  
Reference: Enders, chapter 4.4

### Univariate Time Series Analysis --- Modeling the Conditional Variance

1. Autoregressive Conditional Heteroscedastic (ARCH) models: model selection, estimation, hypothesis test, forecast, etc.
2. Generalized ARCH (GARCH) models
3. ARCH-in-Mean (ARCH-M) model
4. Applications: forecast confidence intervals with GARCH effects, modeling U.K. inflation using ARCH model, modeling U.S. inflation using GARCH model, estimating time-varying risk premium in the term structure using ARCH-M model

### Applications:

1. Testing for GARCH effects in monthly dollar/sterling exchange rates  
Reference: Pesaran & Pesaran, chapter 12
2. Modeling volatility in stock prices and excess equity return  
Reference: Pesaran & Pesaran, chapters 10 & 12

### Multivariate Time Series Analysis --- Vector Autoregressions, Cointegration, and Error Correction Models

1. Unrestricted stationary VAR: estimation, model selection, impulse-response analysis, forecast error variance decomposition
2. Granger causality: bivariate Granger causality test, block Grange causality test
3. Restricted stationary VAR: SUR estimation
4. Structural VAR: identification, estimation, impulse-response analysis, hypothesis test
5. Unit roots in multivariate time series: vector Functional Central Limit Theory, VAR with unit roots, spurious regression
6. Cointegration and co-movements in trended time series
7. Granger representation theorem and error correction models (ECM)
8. Single equation tests for cointegrating relations
9. Johansen's maximum likelihood analysis of cointegrated systems: the ML algorithm of ECM, likelihood ratio tests for the rank of cointegration, testing hypothesis about cointegrating vectors

#### Applications:

1. Modeling and forecasting G7 output growth rates using stationary VAR.  
Reference: Pesaran & Pesaran, chapter 15
2. Modeling the UK term structure of interest rates using cointegrating VAR.  
Reference: Pesaran & Pesaran, chapter 16

### Structural Breaks and Time Series Models with Regime Changes

1. Tests for structural break: Chow's test, CUSUM and CUSUMSQ tests, recursive regression
2. Hansen's test for structural break
3. Markov Switching model
4. Threshold VAR (TVAR) model

#### Applications:

1. Application of Markov Switching model to U.S. Business Cycle.
2. Testing for PPP in the TVAR framework.

## Readings

References with \*\* are highly theoretical. References with \* give good combination of econometric theory and empirical application. Others involve mostly empirical applications.

### Suggested Readings for Univariate Time Series Modeling, Unit Roots and Persistence

- \*\* Baillie, R. (1996), "Long Memory Processes and Fractional Integration in Econometrics," *Journal of Econometrics*, 73, 5-59.
- \*\* Bhargava, A. (1986), "On the Theory of Testing for Unit Roots in Observed Time Series," *Review of Economic Studies*, 53, 369-384.
- \*\* Beveridge, S. and C.R. Nelson (1981), "A New Approach to the Decomposition of Economic Time Series into Permanent and Transitory Components with Particular Attention to Measurement of the Business Cycle," *Journal of Monetary Economics*, 7, 151-174.
- \* Cochrane, J.H. (1988), "How Big is the Random Walk in GNP?" *Journal of Political Economy*, 96, 893-920.
- \*\* Dickey, D.A. and W.A. Fuller (1979), "Distribution of the Estimators of Autoregressive Time Series with a Unit Root," *Journal of American Statistical Association*, 74, 427-431.
- \*\* Elliott, G., T.J. Rothenberg and J.H. Stock (1996), "Efficient Tests for an Autoregressive Unit Root," *Econometrica*, 64, 813-836.
- \* Granger, C.W.J. and P. Newbold (1974), "Spurious Regression in Econometrics," *Journal of Econometrics*, 2, 111-120.
- \*\* Kwiatkowski, D., P. Phillips, P. Schmidt, and Y. Shin (1992), "Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root," *Journal of Econometrics*, 54, 159-178.
- \*\* Leybourne, S. and B. McCabe (1994), "A Consistent Test for a Unit Root," *Journal of Business and Economic Statistics*, 12, 157-166.
- \* Nelson, C.R. and C.I. Plosser (1982), "Trends and Random Walk in Macroeconomic Time Series: Some Evidence and Implications," *Journal of Monetary Economics*, 10, 139-162.
- \* Perron, P. (1989), "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis," *Econometrica*, 57, 1361-1401.

- \*\* Phillips, P.B.C. (1987), "Time Series Regression with a Unit Root," *Econometrica*, 55, 277-301.
- \*\* Phillips, P.B.C. and P. Perron (1988), "Testing for a Unit Root in Time Series Regression," *Biometrika*, 75, 335-346.
- \*\* Said, E.S. and D.A. Dickey (1984), "Testing for Unit Roots in Autoregressive Moving Average Model of Unknown Order," *Biometrika*, 71, 599-607.
- \*\* Sargan, J.D. and A. Bhargava (1983), "Testing Residuals from Least Squares Regression for Being Generated by the Gaussian Random Walk," *Econometrica*, 51, 153-174.
- \*\* Schmidt, P. and P.C.B. Phillips (1992), "LM Tests for a Unit Root in the Presence of Deterministic Trends," *Oxford Bulletin of Economics and Statistics*, 54, 257-287.
- \*\* Tanaka, K. (1990), "Testing for a Moving Average Unit Root," *Econometric Theory*, 6, 433-444.

Suggested Readings for Modeling Conditional Heteroscedasticity

- \*\* Bollerslev, T. (1986), "Generalized Autoregressive Conditional Heteroskedasticity," *Journal of Econometrics*, 31, 307-327.
- Bollerslev, T. (1987), "A Conditionally Heteroskedastic Time Series Model for Speculative Prices and Rates of Return," *Review of Economic and Statistics*, 69, 542-547.
- \* Bollerslev, T., R.Y. Chou and K.F. Kroner (1992), "ARCH modelling in Finance: A Review of the theory and Empirical Evidence," *Journal of Econometrics*, 52, 5-60.
  - \*\* Diebold, F.X. and M. Nerlove (1989), "The Dynamics of Exchange Rate Volatility: A Multivariate Latent Factor ARCH Model," *Journal of Applied Econometrics*, 4, 1-21.
  - \*\* Engle, R.F. (1982), "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation," *Econometrica*, 50, 987-1007.
  - \*\* Engle, R.F., D. Lilien and R. Robins (1987), "Estimating Time Varying Risk Premia in the Term Structural: The ARCH-M Model," *Econometrica*, 55, 391-407.
  - \* Engle, R.F. and V.K. Ng (1993), "Measuring and Testing the Impact of News on Volatility," *Journal of Finance*, 48, 1749-1778.
- Holt, M. and S. Aradhyula (1990), "Price Risk in Supply Equations: An Application of GARCH Time Series Models to the U.S. Broiler Market," *Southern Economic Journal*, 57, 230-242.

\*\* Nelson, D.B. (1991), "Conditionally Heteroskedasticity in Asset Returns: A New Approach," *Econometrica*, 59, 347-370.

#### Suggested Readings for Vector Autoregression

\* Blanchard, O.J. and D. Quah (1989), "The Dynamic Effects of Aggregate Demand and Supply Disturbances," *American Economic Review*, 79, 655-673.

\*\* Granger, C.W.J (1969), "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica*, 37, 424-438.

\* Hsiao, C. (1982), "Autoregressive Modeling and Causal Ordering of Economic Variables," *Journal of Economic Dynamics and Control*, 4, 243-259.

\*\* Koop, G., M.H. Pesaran and S.M. Potter (1996), "Impulse Response Analysis in Nonlinear Multivariate Models," *Journal of Econometrics*, 74, 119-147.

Sims C.A. (1972), "Money, Income and Causality," *American Economic Review*, 62, 540-552.

\* Sims C.A. (1980), "Macroeconomics and Reality," *Econometrica*, 48, 1-48.

Sims C.A. (1986), "Are Forecasting Models Usable for Policy Analysis?" *Federal Reserve Bank of Minneapolis Quarterly Review*, Winter 1986, 3-16.

\*\* Wold, H.O.A. (1960), "A Generalization of Causal Chain Models," *Econometrica*, 28, 443-463.

\* Zellner, A. (1962), "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," *Journal of the American Statistical Association*, 57, 348-368.

#### Suggested Readings for Cointegration Analysis

\* Davidson J.E.H., D.F. Hendry, F. Srba and S. Yeo (1978), "Econometric Modeling of the Aggregate Time-Series Relationship between Consumers' Expenditure and Income in the United Kingdom," *Economic Journal*, 88, 661-692.

\*\* Engle, R.F. and C.W.J. Granger (1987), "Co-integration and Error Correction: Representation, Estimation and Testing," *Econometrica*, 55, 251-276.

\* Granger, C.W.J. (1983), "Co-Integrated Variables and Error-Correcting Models," UCSD, Discussion Paper 83-13.

\*\* Granger, C.W.J. and J.L. Lin (1995), "Causality in the Long-Run," *Econometric Theory*, 11, 530-536.

- \* Granger, C.W.J. and P. Newbold (1974), "Spurious Regressions in Econometrics," *Journal of Econometrics*, 2, 111-120.
- \*\* Hsiao, C. (1997a), "Cointegration and Dynamic Simultaneous Equation Model," *Econometrica*, 65, 647-670.
- \*\* Hsiao, C. (1997b), "Statistical Properties of the Two-Stage Least Squares Estimator under Cointegration," *Review of Economic Studies*, 64, 385-398.
- \*\* Johansen, S. (1988), "Statistical Analysis of Cointegrated Vectors," *Journal of Economic Dynamics and Control*, 12, 231-254.
- \*\* Johansen, S. (1991), "Estimation and Hypothesis Testing of Cointegrating Vectors in Gaussian Vector Autoregressive Models," *Econometrica*, 59, 1551-1580.
- \* Johansen, S. and K. Juselius (1992), "Testing Structural Hypotheses in a Multivariate Cointegration Analysis of the PPP and the UIP for UK," *Journal of Econometrics*, 53, 211-244.
- \*\* Phillips, P.B.C. (1986), "Understanding Spurious Regressions in Econometrics," *Journal of Econometrics*, 33, 311-40.
- \*\* Phillips, P.B.C. (1991), "Optimal Inference in Cointegrating System," *Econometrica*, 59, 283-306.
- \*\* Phillips, P.B.C. (1995), "Fully Modified Least Squares and Vector Autoregression," *Econometrica*, 63, 1023-1078.
- \*\* Phillips, P.B.C. and B.E. Hansen (1990), "Statistical Inference in Instrumental Variables Regression with I(1) Processes," *Review of Economic Studies*, 57, 99-125.
- \*\* Phillips, P.B.C. and S. Ouliaris (1990), "Asymptotic Properties of Residual Based Tests for Cointegration," *Econometrica*, 58, 165-93.
- \*\* Sims, C.A., J.H. Stock and M.W. Watson (1990), "Inference in Linear Time Series Models with Some Unit Roots," *Econometrica*, 58, 113-144.
- \*\* Stock, J.H. (1987), "Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors," *Econometrica*, 55, 1035-1056.
- \*\* Stock, J.H. and M.W. Watson (1988), "Testing for Common Trends," *Journal of the American Statistical Association*, 83, 1097-1107.
- \*\* Toda, H.Y. and P.C.B. Phillips (1993), "Vector Autoregression and Causality," *Econometrica*, 61, 1367-1393.

\*\* Toda, H.Y. and T. Yamamoto (1994), "Statistical Inference in Vector Autoregressions with Possibly Integrated Processes," *Journal of Econometrics*, 66, 225-250.

#### Suggested Readings for Structural Breaks and Regime-Switching Models

Bollen, N.P.B., S.F. Gray and R.E. Whaley (2000), "Regime Switching in Foreign Exchange Rates: Evidence from Currency Option Price," *Journal of Econometrics*, 94, 239-276.

\*\* Brown, R.L., J. Durbin, and J.M. Evans (1975), "Techniques for Testing the Constancy of Regression Relations over Time," *Journal of the Royal Statistical Society B*, 37, 149-192.

\* Chow, G.C. (1960), "Test of Equality between Sets of Coefficients in Two Linear Regressions," *Econometrica*, 28, 591-605.

Dahlquist M. and S.F. Gray (2000), "Regime-Switching and Interest Rates in the European Monetary System," *Journal of International Economics*, 50, 399-419.

\* Engel, C. and J.D. Hamilton (1990), "Long Swings in the Dollar: Are They in the Data and Do Markets know it?," *American Economic Review*, 80, 689-713.

\*\* Hamilton, J.D. (1989), "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle," *Econometrica*, 57, 357-384.

\*\* Hamilton, J.D. (1996), "Specification Testing in Markov-Switching Time Series Models," *Journal of Econometrics*, 70, 127-157.

\* Hansen, B.E. (1992), "Testing for Parameter Instability in Linear Models," *Journal of Policy Modeling*, 14, 517-533.

\*\* Tsay, R.S. (1989), "Testing and Modeling Threshold Autoregressive Processes," *Journal of American Statistical Association*, 84, 231-240.

\* Taylor A.M. (2001), "Potential Pitfalls for the Purchasing-Power-Parity Puzzle? Sampling and Specification Biases in Mean-Reversion Tests of the Law of One Price," *Econometrica*, 69, 473-498.