Economics 8828 – Fall 2014
Seminar in Time Series Econometrics
TR 12:30-1:45 – Econ 5
Professor Robert McNown

Robert McNown
Office: Economics 109 Hours: Monday, 3:00-5:00
Telephone: 303-492-8295 Thursday 2:00-3:30
Email: robert.mcnown@colorado.edu

Class Content

The primary objective of this course is to survey models and methods of modern time series econometrics, with particular emphasis on problems of inference when variables are nonstationary. Traditionally, regressions with time series ignored the issue of non-stationarity, proceeding as though the well-established properties of standard estimators hold even in the nonstationary environment. This complacency was upset by simulation studies by Granger and Newbold (1974) and analytical work by Phillips establishing that regression estimators and test statistics do not have standard distributions in models with non-stationary or integrated variables. Nelson and Plosser (1982) provided empirical evidence that typical macroeconomic time series are non-stationary, integrated processes, to further undermine traditional practices of time series regressions. Subsequently, Engle and Granger (1987) provided the framework of cointegration for modeling relations among integrated time series, and established the connection between cointegration and the dynamic error correction models that David Hendry and his disciples had pioneered. Following the seminal work by Engle and Granger, there has been a flowering of research extending their ideas and applying these methods to a variety of estimation problems.

Although time series econometrics is commonly seen as providing methods for the analysis of macroeconomic models, the scope of applicability is considerably wider. Any set of variables that is observed over time is appropriate for time series modeling. This could include models of supply and demand, production functions, input demand and supply relations, and other standard microeconomic models. More importantly, the entire body of panel data analysis necessarily involves a time dimension, although issues of non-stationarity are often ignored (incorrectly) in panel estimation.

In this course you will be introduced to the statistical foundations, tests, and estimation procedures appropriate for work with integrated time series. The univariate analysis will emphasize tests for unit roots, considering the design of powerful tests and tests appropriate in the face of structural change. Multivariate analysis is grounded in vector autoregression models and cointegration analysis, including Johansen's powerful maximum likelihood framework and the more recent autoregressive distributed lag (ARDL) approach. We will also consider the procedures for testing for unit roots and cointegration within panels, and the implications of non-stationarity for panel data analysis.

In addition to asymptotic theory, Monte Carlo methods and bootstrap simulations have become essential tools for modern time series analysis. You will learn to build simulation programs using the EViews programming language that you can adapt to your research project for the course, ideally combining econometric methodology and practical applications. Extensions of univariate and multivariate methodologies to issues of seasonality, structural breaks, trend extraction (decomposition), conditional heteroscedasticity (ARCH models), and non-linear time series models are examples of topics that are appropriate for student projects or presentations.

Evaluation and Administration

There will be one midterm examination and a take-home final exam, each counting towards 25% of your course grade. There will also be some computer exercises and problem sets counting another 15% of the final grade. The remaining 35% of your grade will be based on your individual project (25%) and a class presentation of an article on econometric methodology (10%), both described below.

Please see the addendum to this syllabus for policies concerning observance of religious holidays, classroom conduct, accommodation of disabilities, honor code, and discrimination and harassment. Please contact me promptly if you have any problems that we need to discuss.

Individual Projects

You will each be responsible for an individual term project on time series econometrics. Ideally your project should have both a theoretical or analytical component and an application, and the methodology must go beyond what we cover in class. To make this assignment more concrete, an example of an appropriate project could involve allowing for structural breaks in tests of non-stationarity (unit roots). Although we will cover unit root testing in some depth, we will touch on this particular issue, there is now a huge literature presenting new tests and applications. The analytical component of the project would present the statistical foundations behind one or more of these tests. Then the tests could be applied to one or more time series of interest as the applied component. Alternatively, the applied component could be a Monte Carlo or bootstrap simulation that demonstrates the performance of a test or procedure in a particular context.

Some general topics that would be suitable for a term project include: (1) ARCH & GARCH models; (2) tests for unit roots in the context of structural breaks; (3) unit roots and cointegration in panels; (4) decomposing time series into trend and stationary components; (5) spurious regressions; (6) seasonal unit roots and cointegration; (7) regime switching models; (8) cointegration with series of mixed or higher orders of integration; (9) alternative bootstrap procedures for time series models. You are not limited to these topics, but I present these as suggestions only.

To assure that your project is appropriate, you should prepare a proposal describing (1) the econometric procedure you will investigate, (2) some key references to the relevant econometric theory, (3) the data set (empirical or simulated) and model to which you plan to apply the procedure, and (4) the data sources. One or two pages should suffice for this proposal, and it should be submitted to me by **September 25.** You are encouraged to discuss your project idea with me before submitting a proposal, or at any time while you are working on the project. Your final project is due on **Tuesday, December 9**. Late submissions are penalized by 10% of the score if received by December 12, or by 20% if submitted after December 12.

Computer Projects and Problem Sets

To get practical experience with some of the econometric methods discussed in the course, you will complete several computer exercises using EViews, which is available in our Economics computer labs. Since we have a site license, you may purchase your own copy of EViews at a sharply reduced rate of approximately $100; visit www.eviews.com for more information. The computer exercises are designed to give you some experience applying the procedures that are discussed in class. You will be asked to submit relevant output and answers to exercises requiring some interpretation of the output. Instructions for the use of Eviews, the exercises, and the data sets will be posted on our D2L site. If you prefer to work with alternative software, such as Stata or R, that is fine with me, but I will not be able to provide much assistance in the use of these programs. Some of our exercises will require you to go beyond the built-in modules of the programs, building your own program commands to run simulations, for example.

I will also design several problem sets that require you to extend the mathematical presentation from class into new areas. Collaboration on the computer exercises and problem sets is acceptable, as long as you inform me about this in advance.

Article Presentation

In keeping with the seminar format, each student will be responsible for a presentation to the class of an article on econometric methodology. Most likely, but not necessarily, this would be an article that is related to your term project. I will help each of you with the selection of your article to make sure it can be presented effectively in one class period. We will schedule the presentations so that they fit the topics we are covering in class or in the assigned readings. I have listed below a number of articles that would be appropriate for student presentations. Each student should choose an article and sign up with me for the presentation topic and date on or before **September 18** and the first presentations will begin on or around September 30. Two or three presentations will be given at the scheduled time of our final exam (December 18: 4:30 – 7:00).

Your presentation will be based on the clarity of presentation, the use of visual aids, your ability to respond to questions from the class, and how well you motivate the topic in terms of its relation to this course, its connection to a larger literature, or practical lessons for future research.

Prior to the presentation all students are urged to read either the article or the corresponding pages from the text by Enders. In the past students have found it particularly useful if handouts presenting the main points of the presentation (e.g., copies of the slides or overheads) were made available for the group.

Articles for Student Presentations and Term Projects

I have listed here the articles that are suitable for student presentations and that offer ideas for term projects. However, I am open to presentations on other paper as well if there are other topics of interest to you that are also related to our course. The articles listed under supplemental readings provide some further possibilities. Other topics in time series analysis that are not covered in this syllabus but that could be appropriate are spatial autocorrelation, fractional unit roots & cointegration, structural VARs, and nonlinear models. In addition, there are sections of Enders' text that present additional topics that could also be of interest.

1.Baxter, Marianne, and Robert King, "Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series," Review of Economics and Statistics 81 (Nov. 1999) 575-593. *This paper presents procedure for extracting components of different frequencies (e.g., seasonal, cyclical, and trend) from a time series. Although the presentation is based on spectral analysis, the application procedure is very straightforward and is available in EViews.*

2.Engle, Rob, D. Lilien, and R. Robins, "Estimating Time-Varying Risk Premia in the Term Structure: The ARCH-M Model. Econometrica 55 (1987) 391-407. *Extends the ARCH model to allow the conditional variance to enter the regression equation.* And

Engle, Rob, "GARCH 101: The Use of the ARCH/GARCH Models in Applied Econometrics," *Journal of Economic Perspectives* 15 (Fall 2001) 101-116. *This paper presents a simple illustration of the use of the ARCH model.*

3. Granger, C.W.J., "Some Recent Developments in a Concept of Causality," Journal of Econometrics 39 (1988) 199-211. *Granger discusses several issues in interpretation of tests of Granger-causality. An appropriate companion piece is the short paper by Dufour and Tessier (1993) "On the Relationship between Inpulse Response Analysis, Innovation Analysis, and Granger Causality,"* Economics Letters 42 (1993) 327-333.

4. Granger, C.W.J. and P. Newbold, "Spurious Regressions in Econometrics," Journal of Econometrics 2 (1974), 111-120. *A cautionary tale about regressions with integrated series, this is the first of several papers that have shown how spurious regressions can arise in a variety of situations. Later papers, Newbold and Davies (International Economic Review, 19 (1978) 513-519) and Granger, Clive W J; Hyung, Namwon; Jeon, Yongil. "Spurious Regressions with Stationary Series," Applied Economics 33.7 (Jun 2001): 899-904, are also of interest.*

present interesting extensions.

5.Hylleberg, S., R.F. Engle, C.W.J. Granger, and B. S. Yoo, "Seasonal Integration and Cointegration," Journal of Econometrics 44 (1990) 215-28. *Presents tests for integration and cointegration at the seasonal frequency.*

6. Maddala, G. S. and Shaowen Wu, "A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test," Oxford Bulletin of Economics and Statistics Special Issue, 61 (1999) 631-652. *One strategy for increasing the power of unit root tests is to combine several related time series into a pooled regression. A number of strategies for testing unit roots in panel data sets have been developed in recent years, and this paper provides a lucid review of the issues involved.*

7. Perron, P. "The Great Crash, the Oil Shock, and the Unit Root Hypothesis," Econometrica 57 (1989) 1361-1402. *The seminal paper in a growing literature that considers tests for unit roots in the context of possible structural breaks.*

8 .Engel, Charles, and James D. Hamilton, "Long Swings in the Dollar: Are they in the Data and Do Markets Know It?" American Economic Review 80 (September 1990) 689-713. *This is an interesting application of Hamilton's Markov switching model that has seen extensive applications in macroeconomics and finance.*

Texts

Primary text: Enders, Walter, *Applied Econometric Time Series* Wiley (3rd edition) 2010.

Sections of Enders' text that are not assigned may be suitable topics for individual student projects. For example, Chapter 3 on modeling volatility (ARCH and GARCH models in particular) may be of interest to many in the class, but it is not a topic I plan to present.

A useful reference for your term project is

Maddala, G. S. and In-Moo Kim, *Unit Roots, Cointegration, and Structural Change* Cambridge: Cambridge University Press (1998) This is an excellent survey of the main topics of modern time series econometrics with excellent bibliographies at the end of each chapter. I am happy to loan out my copy at any time.

Schedule: Topics, Reading Assignments, and Computer Exercises

I. Basic concepts, mathematical and statistical foundations.

Readings: Enders, Chapter 1. Introductory examples; difference equations, their solutions, and stability conditions.

Class: Major developments in time series econometrics over the past 30 years; some basic time series models; polynomials in the lag operator.

Computer exercise 1. Introduction to Eviews (due 9/2)

II. Stationary vs. non-stationary processes

Readings**:** Enders, Chapter 2 (sections 1-8). ARMA models, stationarity conditions; basic empirical tools of univariate analysis: correlogram and Q-statistics, partial autocorrelation fct., Box-Jenkins modeling strategy. [I will ask you to work through this material on your own, reinforced with a problem set and computer exercise.] Pages from Hamilton, *Time Series Analysis* on distribution theory for unit root processes [on D2L].

Class: Univariate distribution theory for unit root processes.

Computer exercise 2. ARMA modeling (due 9/9)

Problem set 1. Difference equations; lag operator polynomials; ARMA modeling. (due 9/16)

III. Unit root tests.

Readings: Enders, Chapter 4. Schwert (1989). Perron (1992). Zivot and Andrews (2002) Trend stationary (TS) vs. difference stationary (DS) processes: properties; the Dickey-Fuller test. Monte Carlo simulation of TS and DS models. Alternatives to and extensions of the Dickey-Fuller test for unit roots. Bootstrap simulations of unit root test statistics (Enders, Appendix 4.1)

Class: coverage of these same topics with further emphasis on tests for unit roots in the presence of structural breaks and panel unit root tests. Class time will also be used to learn EViews programming.

Computer exercise 3: unit root testing (due 9/23)

Computer exercise 4: programming Eviews for a Monte Carlo experiment (due 9/30)

Problem set 2: Weiner processes and unit root testing (due 10/7)

IV. Vector Autoregressions

Readings: Enders, Chapter 5. Stock and Watson (2001). Todo and Yamamoto (1995) Motivations; empirical procedures; Granger causality, impulse response functions, variance decompositions; structural VARs.

Class: coverage of same topics.

Computer exercise 5: programming Eviews for bootstrap simulations (due 10/21)

Computer exercise 6: vector autoregressions (due 10/30)

V. Cointegration and error correction models.

Readings: Enders, Chapter 6. Pesaran, Shin, and Smith (2001). Stock and Watson (1993). Concepts and mathematics of cointegration and error correction; Granger representation theorem; least squares approaches to cointegration testing and modeling; Johansen's maximum likelihood approach using Vector Error Correction Models.

Class: Coverage of these topics will be extended to consider the ARDL Bounds test for cointegration and dynamic OLS and GLS methods for estimating cointegrating equations. The correct maximum likelihood procedure of Johansen will be presented instead of Enders' heuristic approach. Issues of cointegration in panels is discussed.

Computer exercise 7: Tests of cointegrating rank; testing restrictions, VECM estimation, impulse response analysis and Granger causality. (due 11/20)

Midterm Examination – October 14

Term Projects Due December 9*

Take-home final: distributed December 2, due December 11*

Students scheduled for class presentations in December may be granted extensions for these due dates.

Additional References

Our text contains numerous references to additional literature. In addition to these, the following references are included for further reading, with an emphasis on time series econometrics.

To add:

Banerjee, Anindya, Juan Dolado, John Galbraith, and David Hendry, Cointegration, Error Correction and the Econometric Analysis of Non-Stationary Data. Oxford: Oxford University Press (1993. A textbook covering both theoretical and practical issues in unit root testing and cointegration. This text is a level above Enders' text in theoretical rigor, but not as demanding and Hamilton's text.

Campbell, John and Pierre Perron, "Pitfalls and Opportunities: What Macroeconomists Should Know About Unit Roots," NBER Macroeconomics Annual 1991. Cambridge: MIT Press (1991). A survey of the implications of nonstationarity for traditional econometric practice, with critical comments by Cochrane and Miron.

DeJong, D.N. et al. "Integration vs. Trend Stationarity in Macroeconomic Time series," Econometrica 60 (1992) 423-434.

DeJong, D.N., and C. H. Whiteman, "Reconsidering Trends and Random Walks in Macroeconomic Time Series," Journal of Monetary Economics, 28 (1991) 221-254. A pair of articles that presents a forceful critique of unit root testing and the conclusion that most macroeconomic time series are I(1).

Doldado, Juan, Tim Jenkinson, and Simon Sosvilla-Rivero, "Cointegration and Unit Roots," Journal of Economic Surveys 4 (1990) 249-73. A survey of this literature up to 1990.

Engel, Charles, and James D. Hamilton, "Long Swings in the Dollar: Are they in the Data and Do Markets Know It?" American Economic Review 80 (September 1990) 689-713. *This is an interesting application of Hamilton's Markov switching model that has seen extensive applications in macroeconomics and finance.*

Engle, Rob, and C.W.J. Granger, "Cointegration and Error-Correction: Representation, Estimation and Testing," Econometrica 55 (March 1987) 251-76. The original presentation of the concept of cointegration and its connection to error correction models.

Engle, Rob, and C.W.J. Granger, (eds.) Long-Run Economic Relationships: Readings in Cointegration Oxford: Oxford University Press (1991). A collection of readings on cointegration.

Engle, Rob, David Hendry, and J. Richard, "Exogeneity," Econometrica 51 (1983) 277-304. *This paper establishes the modern concept of exogeneity and related terms.*

Gabriel, Vasco J. "Tests for the Null Hypothesis of Cointegration: A Monte Carlo Comparison," Econometric Reviews 22 (2003) 411-435. *Presents Monte Carlo evidence on the performance of several alternative tests for cointegration, all with the null*

hypothesis of stationary errors (cointegration) as opposed to the more common null of non-cointegration.

Gonzalo, Jesus "Five alternative methods of estimating long-run equilibrium relationships," Journal of Econometrics 60 (1994) 203-233. *The theoretical sections provide a mathematical integration and description of alternative cointegration models, and the Monte Carlo study evaluates these alternative estimators.*

Granger, Clive W J; Hyung, Namwon; Jeon, Yongil. "Spurious Regressions with Stationary Series," Applied Economics 33.7 (Jun 2001): 899-904.

Hamilton, James, Time Series Analysis Princeton: Princeton University Press (1994). A comprehensive and often advanced presentation of time series analysis. Includes statistical distribution theory relevant to nonstationary processes.

Handbook of Econometrics, volumes 1-4, Amsterdam: North Holland. Of particular relevance to our topics on time series are two chapters in volume 4: Chapter 46 by James Stock, "Unit Roots, Structural Breaks, and Trends" and Chapter 47 by Mark Watson, "Vector Autoregression and Cointegration." These chapters update earlier surveys of these topics with numerous references to theoretical and applied papers.

Harris, Richard, Using Cointegration Analysis in Econometric Modelling London: Prentice Hall (1995). This is a hands-on text with examples demonstrating how to do empirical analysis with nonstationary data.

Harvey, Andrew, Forecasting, Structural Time Series Models and the Kalman Filter. Cambridge: Cambridge University Press (1989). Harvey promotes the use of state space models, estimated by the Kalman filter, as an approach to capturing stochastic trends and short term fluctuations characteristic of economic time series. This is an alternative to the Box-Jenkins and Dickey-Fuller approaches emphasized in the class.

Inder, Brett, "Estimating Long-Run Relationships in Economics," Journal of Econometrics57 (1993) 53-68. *This Monte Carlo study compares several least-squares approaches to the estimation of cointegrating relations*.

Johansen, Soren, Likelihood-Based Inference in Cointegrated Vector Autoregressive Models, Oxford: Oxford University Press (1995). This is a comprehensive presentation of Johansen's maximum likelihood approach to modeling, estimating, and testing systems of cointegrating relations.

Johansen, Soren, and K. Juselius, "Maximum Likelihood Estimation and Inference on Cointegration: with Applications to the Demand for Money," Oxford Bulletin of Economics and Statistics, vol. 52 (1990) 169-210. This is a fairly accessible presentation of Johansen's maximum likelihood approach to cointegration modeling with a useful empirical example.

Journal of Business and Economic Statistics 10 (June 1992). A special issue devoted to tests of unit roots and structural change. Tests with unknown break points are presented by Perron and Vogelsang, and by Zivot and Andrews.

Journal of Econometrics volume 80, No. 2 (1997) is a special issue on cointegration and dynamics in econometrics. Especially recommended are Li and Maddala's article on bootstrapping of cointegrating regressions, and Entorf's paper on spurious regressions in a panel data model.

Journal of Economic Dynamics and Control volume 12 (June-Sept. 1988) is a special issue containing some early and important papers on unit roots and cointegration.

Journal of Economic Surveys volume 12, no. 5 (December 1998) *A special issue of surveys on practical issues in unit root testing and cointegration.* The article by Haldrup is a fairly intelligible paper on I(2) modeling.

Journal of Policy Modeling volume 14 (August 1992) is a special issue on Cointegration, Exogeneity, and Policy Analysis.

Juselius, Katarina, *The Cointegrated VAR Model*, Oxford, Oxford University Press (2006). *This is a comprehensive and up-to-date presentation of the Johansen approach to cointegration modeling.*

King, R.G., C.I. Plosser, J.H. Stock, and M.W. Watson, "Stochastic Trends and Economic Fluctuations," American Economic Review 81 (September 1991) 819-840. *Application of cointegration and common trends analysis to real business cycle model.*

Kwiatkowski, Denis, et al. (KPSS) "Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root," Journal of Econometrics 54 (1992) 159-178. *Presents a test that reverses the null and alternative hypotheses from those of the Dickey-Fuller approach.*

Lee, J., and M. Strazicich, "Minimum Lagrange Multiplier Unit Root Test with Two Structural Breaks," Review of Economics and Statistics. 85 (Nov. 2003) 1082-89. *Considered by some to be the state of the art in unit root testing with structural breaks.*

Li, H., and G. S. Maddala, "Bootstrapping Tirne Series Models," Econometric Reviews, 15(1996), 115-158.

Li, H., and G.S. Maddala, "Bootstrapping Cointegrating Regressions," Journal of Econometrics 80 (1997) 297-318. This pair of articles surveys the use of the bootstrap methodology in some of the most important areas of time series econometrics. Li and Maddala provide numerous practical suggestions for best practices in the design of the bootstrap procedures.

Maddala, G. S. and In-Moo Kim, Unit Roots, Cointegration, and Structural Change Cambridge: Cambridge University Press (1998). This is an excellent, wide-ranging survey of models and methods for handling nonstationary variables.

Maddala, G. S. and Shaowen Wu, "A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test," Oxford Bulletin of Economics and Statistics Special Issue,

61 (1999) 631-652. *One strategy for increasing the power of unit root tests is to combine several related time series into a pooled regression. A number of strategies for testing unit roots in panel data sets have been developed in recent years, and this paper provides a lucid review of the issues involved.*

Nelson, Charles, and Charles Plosser, "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications," J. of Monetary Economics 10 (1982) 130-62. An early application of unit root tests to economic time series. They find most of the series studied to be integrated, a result contested by later researchers using different methods. Their data set is available for further investigations.

Nelson, Charles R., and Heejoon Kang, "Pitfalls in the Use of Time as an Explanatory Variable in Regression," Journal of Business and Economic Statistics 2 (1984) 73-82. *The traditional practice in regression analysis with trended variables is to control for deterministic trends. This article shows what happens under such treatment if the variables actually have stochastic trends.*

Ng, S. and P. Perron, "Lag length selection and the construction of unit root tests with good size and power," Econometrica 69 (2001) 1519-1554. They have combined insights from several alternative approaches to unit root testing to develop test procedures that are currently recognized as the state of the art in unit root testing. These test procedures are also appropriate, with suitable modifications, as residual based tests for cointegration. Their procedures are programmed into recent versions of EViews.

Oxford Bulletin of Economics and Statistics volume 48 no. 3 (1986) is a special issue containing early papers on cointegration and error correction models.

Oxford Bulletin of Economics and Statistics Volume 54, No. 3 (August 1992) is another special issue on Testing Integration and Cointegration.

Oxford Bulletin of Economics and Statistics Volume 61, No. 4 (Supplement 1999) is a special issue on panel unit root and cointegration. The article by Maddala and Wu is a particularly useful review of the various unit root tests that have been proposed.

Pantula, S.G., G. Gonzalez-Farias, and W.A. Fuller, "A Comparison of Unit-Root Test Criteria," Journal of Business and Economic Statistics 12 (October 1994) 449-459. *Presents several extensions of the Dickey-Fuller test and evaluates these in a Monte Carlo study.*

Perron, Pierre, "Testing for a Unit Root in a Time Series with a Changing Mean," Journal of Business and Economic Statistics 8 (1990) 153-62.

Perron, Pierre, "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis," Econometrica 60 (January 1992) 119-43. The first of this pair or articles presents the test of a unit root against the stationary alternative with change in mean or change in trend slope. The second applies the test to the Nelson-Plosser data.

Pesaran, M.H., Yongcheol Shin, and Richard J. Smith, "Bounds Testing Approaches to the Analysis of Level Relationships," Journal of Applied Econometrics. **16 (2001)**: 289–326. This article presents the ARDL methodology for testing cointegration when the

explanatory variables are of uncertain orders of integration. The paper includes formal distribution theory, interpretive considerations, and tables of critical values for the tests.

Phillips, Peter, and Mico Loretan, " Estimating Long Run Economic Equilibria," Review of Economic Studies 58 (1991) 407-36. They review several procedures for estimating cointegrating equations, including a quite straightforward, single-equation procedure that is efficient and yields asymptotically valid test statistics.

Schwert, G.W., "Tests for Unit Roots: A Monte Carlo Investigation," Journal of Business and Economic Statistics 7 (1989) 147-59. *One of the first Monte Carlo investigations of the comparative properties of several unit root tests. This paper is also a good introduction to the Monte Carlo method.*

Sims, Christopher, "Macroeconomics and Reality," Econometrica 48 (January 1980) 1-49. *The classic presentation of Sims' VAR methodology and critique of traditional structural econometric methods.*

Sims, C., J. Stock, and M. Watson, "Inference in Linear Time Series Models with some Unit Roots," Econometrica. 58 (1990) 113-44. *This is an extremely important article that describes when it is appropriate and when it is not valid to use standard Gaussian distribution theory for inference in VARs with integrated variables.*

Stock, James, and Mark Watson, "Vector Autoregressions," Journal of Economic Perspectives 15 (Fall 2001) 101-116. *This is a very readable introduction to VARs and some of the issues of controversy over their use in policy analysis.*

Stock, J.H., and M.W. Watson,"A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," Econometrica 61 (1993) 783-820. *Consistent with the title, the authors present a least-squares based approach to estimating cointegrating relations that can be used with systems involving I(1), I(2), or higher orders of integration.*

Toda, H.Y., and T. Yamamoto, "Statistical inference in vector autoregressions with possibly integrated processes," *J. of Econometrics* 66 (1995) 225-250. They present a simple strategy for estimation and testing with VARs when variables may or may not be integrated and/or cointegrated.

Vogelsong, T.J., and P. Perron, "Additional Tests for a Unit Root Allowing for a Break in the Trend Function at an Unknown Time," International Economic Review 39 (1998) 1073-1100. *This article presentes a comprehensive treatment of testing for unit roots in the context of a variety of structural breaks.*

Zivot, Eric, and d. Andrews, "Further Evidence on the Great Crash, the Oil-Price Shoock, and the Unit root Hypothesis," Journal of Business and Economic Statistics. 20 (2002) 25-44. A widely used test for unit roots allowing for structural break at an unknown point in time.

Addendum: Course Policies

(1) Accommodations for Disabilities:

If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at dsinfo@colorado.edu. If you have a temporary medical condition or injury, see Temporary Medical Conditions: Injuries, Surgeries, and Illnesses guidelines under Quick Links at Disability Services website and discuss your needs with your professor.

(2) Policy for religious observances
Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, I will attempt to accommodate individual needs for religious observances, as long as each student discusses with me in advance their individual needs. See full details of CU's policies towards religious observances at http://www.colorado.edu/policies/fac_relig.html

A comprehensive calendar of the religious holidays most commonly observed by CU-Boulder students is at http://www.interfaithcalendar.org/

(3) **Classroom Behavior** policy

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, color, culture, religion, creed, politics, veteran's status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See policies at http://www.colorado.edu/policies/classbehavior.html and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

(4) Policies towards Discrimination and Harassment:

The University of Colorado Boulder (CU-Boulder) is committed to maintaining a

positive learning, working, and living environment. The University of Colorado does not discriminate on the basis of race, color, national origin, sex, age, disability, creed, religion, sexual orientation, or veteran status in admission and access to, and treatment and employment in, its educational programs and activities. (Regent Law, Article 10, amended 11/8/2001). CU-Boulder will not tolerate acts of discrimination or harassment based upon Protected Classes or related retaliation against or by any employee or student. For purposes of this CU-Boulder policy, "Protected Classes" refers to race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, or veteran status. Individuals who believe they have been discriminated against should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Student Conduct (OSC) at 303-492-5550. Information about the ODH, the above referenced policies, and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://hr.colorado.edu/dh/

(5) CU Honor Code:

All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu**; 303-735-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at** http://www.colorado.edu/policies/honor.html **and at** http://honorcode.colorado.edu