EPPS 7370
Time Series Analysis
Fall 2012
Tuesday 4:00-6:45, ECSN 2.112

Instructor	**Teaching Assistant**
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Hours: TR, 1:00-2:00 p.m.	Hours: R 4:00-6:00 p.m.
and by appointment	and by appointment

Description

This course provides an introduction to time series analysis or data organized with respect to time. Topics to be covered include ARIMA, Box-Jenkins models; transfer function analysis; time series regression models; spectral analysis; multiple time series models; ARCH and GARCH; unit root or non-stationary models; Bayesian time series method; non-normal time series; state-space models; and, regime-switching and changepoint models.

Student Learning Objectives

On completing this course, students will be able to:

- Conduct independent analyses of time series data,
- Specify and test the fit of multiple time series model specifications for the same data,
- Forecast time series data over different time horizons, with apprpriate methods of assessment and uncertainty,
- Diagnose misspecification problems in time series models,
- Compare and contrast different time series methods.

Required texts and course materials

Texts

Three required textbooks have been ordered. The others are listed as reference texts you may wish to consult.

Required:

- Brandt, Patrick T. and John T. Williams. 2007. *Multiple Time Series Models*. Thousand Oaks: Sage.
- Cowpertwait, Paul S. P. and Andrew V. Metcalfe. 2009. *Introductory Time Series with R (Use R)*. Berlin: Springer
- Lütkepohl, Helmut and Markus Krätzig, eds. 2004. *Applied Time Series Econometrics*. Cambridge.
- Shumway, Robert and David Stoffer. 2011. *Time Series Analysis and Its Applications: With R Examples*. 3rd Edition. Berlin: Springer-Verlag.

Optional / Reference :

- Namboodiri, Krishnan. 1984. *Matrix Algebra, an introduction.* (if your linear algebra is rusty).
- Simon and Blume (if you linear algebra is rusty, or you need a more advanced reference on matrices, decompositions, optimization, etc.)
- Chatfield, Chris. 2004. *The Analysis of Time Series: An Introduction, Sixth, Ed.* Boca Raton: Chapman & Hall / CRC
- Hamilton, James. 1994. *Time Series Analysis*. Princeton: Princeton University Press (this is a standard reference text).
- Lütkepohl, Helmut. 2005. *New Introduction to Multiple Time Series* Berlin: Springer-Verlag.
- Reinsel, Gregory C. 2003. *Elements of Multivariate Time Series*. Berlin: Springer-Verlag
- Mills, Terence. 1991. *Time Series Techniques for Economists*. Cambridge; Cambridge Unversity Press.
- Harvey, Andrew C. 1990. *The Econometric Analysis of Time Series*. Cambridge: MIT Press.
- Enders, Walter. 2010. *Applied Econometric Time Series, 3rd Edition*. John Wiley & Sons.
- Box, George E.P., Gwilym M. Jenkins, and Gregory C. Reinsel. 2008. *Time Series Analysis: Forecasting and Control*. Wiley.
- Granger, C.W.J. and Paul Newbold. 1986. *Forecasting Economic Time Series* (Second Edition). San Diego, CA: Academic Press.
- Harvey, Andrew. 1989. *Forecasting, Structural Time Series Models and the Kalman Filter*. Cambridge: Cambridge University Press.
- Harvey, Andrew. 1993. *Time Series Models* (Second Edition). Cambridge: MIT Press.
- Hendry, David F. 1995. *Dynamic Econometrics*. Oxford: Oxford University Press.
- Mills, Terrence C. 1990. *Time Series Techniques for Economists*. Cambridge: Cambridge University Press.

I will also reference research papers and articles in the lectures. There may be lists of articles added to the syllabus readings below.

Elearning

Elearning is used in this class for distributing course materials (notes, datasets, code, etc) and to check your progress in the class. If you do not have a computer at home or prefer to work on campus, you may do this at the library or in the many computer labs on campus. You can access the course elearning page at `http://elearning.utdallas.edu`. Additional information about how to use elearning is available at this site as well. You will need a UTD net-id to access this site. elearning is also how I will communicate with you. You are responsible for announcements made through elearning.

Computing

A major component of applied statistics and time series analysis is using computers and data to implement models and test hypotheses. Toward that end, students should be expected to utilize a variety of statistical packages for their work. While no one statistical program will be used for this course, familiarity with several is important because each has their own niche.

I will primarily use `R`. `R` is a widely used, free (open-source) statistical analysis program. The main course text includes examples worked out in `R`. `R` can be downloaded for any computer operating system from `http://www.R-project.org`. This software can be freely downloaded for your own use and is available in the EPPS computer labs in Green Hall. I use `R` for two reasons: it is free and it has more cutting edge methods for time series analysis than those found in other software. If you are not familiar with `R` you should get acquainted with it by looking

at the "Introduction to R" tutorial at `http://cran.r-project.org/doc/manuals/R-intro.html` and . Another useful resource is the Wiki at `http://rwiki.sciviews.org/doku.php`. Finally, a Google-like specific site is `http://rseek.org`.

Depending on the material, I may present models fit with other software. Some software does a better job at some models and methods than others. Examples of these other software packages are

Package	Cost
S-plus	Available at UTD
R	Free
Stata	Available at UTD
SAS	Available at UTD
RATS	Available at UTD
Ox	Free console version
GAUSS	Available at UTD
Matlab	Available at UTD

Any others are acceptable, and you should *not* express reservation about learning additional programs — it is an impediment to your future research and teaching.

For home use (i.e., those who hate to purchase licenses), I highly recommend R, the GNU clone of S-plus. It is free, has great graphics and is well documented. For econometric analysis and time series, I recommend Stata, Ox, or RATS.

I will not spend a great deal of time leading tutorials on statistical software in class. I am happy to have them arranged outside of class. I will also make programs an code available on an as needed basis in several statistical packages to demonstrate techniques. Note that somethings are easier to do in different packages and then convert the data to another format for analysis (e.g., I often construct variables and datasets in Stata and then move them to other software for analysis.) Your best resource for learning and implementing new methods is your peers and the voluminous manuals (either printed or online) that come with statistical software. At the end of the day the other good way to figure something out is to use `www.google.com` (e.g., "vector autoregression" plus Stata or `R`).

Grading, Assignments, and Course Policies

Grading

There will be approximately eight to ten assignments, and two exams. The allocation of the grade is:

- Assignments / Problem Sets: 40%
- Exam I: 30%
- Exam II: 30%

The first exam (approximately during week 8) will have two components: 1) an in-class, time series theory section and 2) an out-of-class component that has you do some applied work. The second exam (date due to be determined) will mainly include applied problems and will be a take-home exam.

Late assignments and papers will be penalized. Late assignments and papers will be penalized 10 points per day. Assignments submitted via e-mail will be considered received by the date and time stamp on the e-mail received in my or the TAs e-mail inbox.

My very strong preference is to not allow incompletes in this course, since you need most of the material completed for later course work. If you believe you will need to take an incomplete you 1) must follow university policy and 2) should contact me as soon as practicable (i.e., not the week of the final exam or the day before the grades are due).

Grades are based on the standard grading scale: A = 100-90, B = 89-80, C = 79-70, etc. Plus or minus grades in a graduate course are at the instructor's discretion.

If you have any questions about your grade on an assignment, please wait until 24 hours after receiving your assignment before discussing the grade with me or the TA. There are no exceptions to this policy.

If you wish to have an assignment re-graded, it must be returned to the me or the TA within two days of the day it was returned (if I am not available that day, ask the staff of the School of Economic, Political and Policy Sciences to leave it in my box). Assignments to be re-graded *must include a memo* stating the reason why you believe they assignment should be re-graded. Finally, re-graded assignments can be graded higher, lower, or the same as the initial grade.

Assignments

Assignments and exams will cover applied and theoretical problems. Assignments should be typewritten as much as possible. I realize that may require setting mathematical text or typographical symbols. This can be done in standard word processing software. Feel free to only use Roman letters. If you are so interested, I can arrange a short tutorial on how to use LaTeX for this task.

Any statistical output or data analysis you do should be fully interpreted and presented as though it were being sent for publication to a journal. *This means that regression or time series output from your statistical package of choice that is copied into a word processor document is unacceptable. You should take the time to typeset the results into a meaningful table or present a well documented and coherent graphical summary of any results.* If you have any questions about what to include in your data output and assignments, consult empirical work in standard journals or ask. Assignments that do not meet this requirement will be returned and not graded until revised.

You may work together on assignments, but each person must turn in separate, independent work. Working together has two benefits. First, it can help you see if you really understand the material (if you can explain it to someone else and convince them that you are right, you probably are). Second, it gets you in the habit of working with others to solve problems (and remember that most research is coauthored!) You do need to be careful about two issues in the course of working together. The first is plaigarism. The second is letting the person who "gets it" do all the work. Just because someone looks like they have solved a problem does not mean it is the correct answer. One of the things I have seen before is that working together can help on the "easy" problems, but on some of the harder problems, a "group" will often come up with the wrong answer. Beware of "groupthink"!

Finally, if you have questions about the assignments, I encourage you to come and ask me or the TA about them. Pounding your head on a desk for 6 days and then coming to get help on day seven (when the assignment is invariably due) is poor form and is not going to help you learn the material. One of the best methods I have found for asking and answering questions for this course is e-mail. The benefit of e-mail is that it forces you to compose your question(s) very specifically and to think through what you are asking logically. In addition, I can generally offer a faster response ia e-mail than if you wait for office hours.

Attendance

It should go without saying that in a class of this size your attendance is easily noted and therefore required. If you are unable to make a class or will be late, advise the instructor as far in advance as possible.

Course conduct

The following rules apply in class:

1. Turn off your cell phone. It is VERY distracting to others. "Off" means that it does not ring OR vibrate. I will ask you to leave if your phone rings. (Exceptions to this policy can be made, come to talk to me.)

2. Do not fall asleep. It is rude and distracting. Bring coffee if you need it (I do when I need it.)

3. Be polite and courteous to your fellow students.

4. Raise your hand when you want to be recognized to answer or ask a question. If you do not raise your hand I will not recognize you or your answer.

5. If you are using a laptop in class or to take notes, don't waste your time or mine checking your e-mail or surfing the web. You will end up wasting my time when you ask me questions that were answered in class when you were on the web.

6. You are reponsible for things: therefore if you miss something I announced or fail to complete an assignment, my response will be "How is this my problem?"

7. Note that this syllabus is not a contract. It is subject to change at my discretion. While we may be studying the social science and statistics, this class is not a democracy.

8. Class starts at 4:00pm. Not 4:15. Be here on time.

9. Respect my time and I will respect yours. We are both busy.

10. *You are expected to be proactive in anticipating and planning for any absences or problems you will have in completing course work.* Make arrangements for possibly missed work prior to the due date is preferable and more likely to be successful than doing it after the due date.

University Policies

University course-related policies about e-mail, course withdrawls, grievance procedures, incomplete grades, disability services, and holiday policies are at `http://go.utdallas.edu/syllabus-policies`.

Course Outline

Readings listed for each week are suggestions. My lectures and discussion will parallel these readings. The readings are listed in order of importance (from most to least important). Feel free to ignore or consult them as needed. I will regularly post or hand out lecture notes on the material we are covering, as appropriate.

In general, I have my own "order" to covering the material. This may differ from the texts, or what others might do. My experience is that this layout of the material works well.

All weeks will include significant applied material. That is, I will either introduce real data to make the points of the lecture or use simulation methods (related to real data problems) to make the case for what we are covering. I generally make available all of the code for what I cover in class so you can use it as well.

For each week there will be readings listed from the main course texts. There will often then be additional readings that serve as illustrations from the literature.

Week 1 (August 28): Basic time series concepts, notation, and `R`

- Shumway and Stoffer, Ch. 1, 2, and Appendix `R`.
- Cowpertwait and Metcalf, Ch. 1.

Weeks 2 (September 4): Autocorrelation, ARMA, difference equations, and related processes

These week will cover difference equations, lag operator arithmetic, stationary ARMA processes, and autocovariance functions.

- Shumway and Stoffer, Ch 3.
- Cowpertwait and Metcalf, Ch. 2, 4, 6.
- You may want to look at some other time series texts to see the notation they use, since it does differ from our texts.

Week 3 (September 11): More ARMA model fitting examples

Most of this week will be working through examples of how to fit and interpret ARIMA models, since these are a basic technique you need to master.

- Shumway and Stoffer, Ch 3.,
- Cowpertwait and Metcalf, Ch. 2, 4, 6.

Week 4 (September 18) : Forecasting and Estimation Here we will cover basic forecasting methods and properties for the models already covered (and those to come). We will also look at forecast probabilities and intervals as a way to understand time series distribution theory. This is getting under the hood of how ARIMA models work and how they can be efficiently estimated and forecasted.

- Shumway and Stoffer, Ch 3, esp. sections 3.5 and 3.6.
- Shumway and Stoffer, Ch 6, esp. sections 6.1 to 6.3.
- Cowpertwait and Metcalf, Ch. 3.

Week 5 (September 25): ARIMA models and the Box-Jenkins method
Until this week we have looked at purely dynamic models in a single variable explained by its history or errors. This week we turn to looking at models based on the simplest kind of time series intervention model, the interrupted time series design. We will look at how these are estimated and interpreted in the context of transfer function models.

- Shumway and Stoffer, Ch 5, esp. sections 5.5 to 5.7.
- Cowpertwait and Metcalf, Ch. 5.
- Wood, B. Dan. 1988. "Principals, Bureaucrats, and Responsiveness in Clean Air Enforcements." *American Political Science Review* 82(1): 213-234.

Week 6 (October 2): Regression and transfer function models
Here we will review basic econometric theory on dynamic single equation models. We will build on this to understand how GLS models are related to systems of equations, IV, and related topics.

- Shumway and Stoffer, Ch 5, esp. sections 5.6 to 5.8.
- Cowpertwait and Metcalf, Ch. 5.
- McAleer, M. and Pagan, A.R. and Volker, P.A. 1985. "What will take the con out of econometrics?" *The American Economic Review*. 75(3):293–307.
- Pagan, Adrian. 1987. "Three Econometrics Methodologies: A Critical Appraisal" *Journal of Economic Surveys* 1(1-2): 3–23.

Week 7 (October 9): Models of time series heterogeneity, changing variances, and long memory This week will cover conditionally heteroscedastic time series models. These are models where one focuses on modeling changes in the variance with an assumption of a simple or nearly fixed mean. This includes ARCH, GARCH, EGARCH, ARFIMA, and related models. These models are central to high-frequency time series analysis, especially in finance.

- Shumway and Stoffer, Ch 5., esp. sections 5.1 to 5.3
- Cowpertwait and Metcalf, Ch. 8.
- DeBoef, Suzanna and Jim Granato. 1997. "Near-Integrated Data and the Analysis of Political Relationships." *American Journal of Political Science* 41(2): 619-640.

Supplemental readings / examples:

- Box-Steffensmeier, Janet M. and Renee M. Smith. 1998. "Investigating Political Dynamics Using Fractional Integration Methods." *American Journal of Political Science* 42(2): 661-689.
- Box-Steffensmeier, Janet M. and Andrew R. Tomlinson. 2000. "Fractional Integration Methods in Political Science." *Electoral Studies*. 19(1): 63-76.
- Leblang, David and Bumba Mukherjee. 2004. "Presidential Elections and the Stock Market: Comparing Markov-Switching and Fractionally Integrated GARCH Models of Volatility." *Political Analysis* 12(3): 296-322.

- Engle, Robert F. 1982. "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation." *Econometrica* 50(4): 987-1007.
- Engle, Robert F. 2001. "The Use of ARCH/GARCH Models in Applied Econometrics." *Journal of Economic Perspectives* 15(4): 157-168.
- Hays, Judith C., John R. Freeman, and Hans Nesseth. 2003. "Exchange Rate Volatility and Democratization in Emerging Market Countries." *International Studies Quarterly* 47(2): 203-288.
- Maestas, Cherie and Robert R. Preuhs. 2000. "Modeling Volatility in Political Time Series." *Electoral Studies* 19(1): 95-110.

Week 8 (October 16): Exam

We will have an in-class, open book, open notes exam this week and then a short take-home exam component.

Weeks 9-10 (October 23 and October 30): Multivariate dynamic regression and Vector Autoregression (VAR)

Time to move beyond the strict / weak exogeneity restrictions we have have for dynamic multiple regression models.

These weeks we will cover vector autoregression (VAR), error correction models (ECM and VECM), which are special cases of VAR.

- Brandt and Williams – all.
- Cowpertwait and Metcalf, Ch. 11.
- Freeman, John. 1983. "Granger Causality and the Time Series Analysis of Political Relationships." *American Journal of Political Science* 27(2): 327-358.
- Stock, James H. and Mark W. Watson. 2001. "Vector Autoregressions." *Journal of Economic Perspectives* 15(4): 101-115.

Week 11 (November 6): Trends and Unit Roots We will cover how to model trends and unit roots from a frequentist perspective. Special attention will be focused on model building and testing and how this works in a multivariate regression and connecting this to error correction models.

- Cowpertwait and Metcalf, Ch. 6 and 11.
- Phillips, P.C.B. 1987. "Time Series with a Unit Root." *Econometrica*. 55: 277-301.
- Phillips, P.C.B. and P. Perron. 1988. "Testing for a Unit Root in Time Series Regression." *Biometrika* 75(2): 335-346.
- Sims, C. A. and Stock J. H. and Watson, M. W. 1990. "Inference in linear time series models with some unit roots." *Econometrica* 58(1): 113–44.

Supplemental readings / examples:

- Maddala, G.S. and In-Moo Kim. 2000. *Unit Roots, Cointegration, and Structural Change*. New York: Cambridge University Press.

Week 12 (November 13): Bayesian time series and Bayesian VAR This week will cover an introduction to Bayesian methods for time series modeling. We will cover the role of prior beliefs, data, and posteriors in time series analysis. We will relate this to what we have learned about VAR models. Finally, we will review the role of informative and non-informative prior beliefs in time series models.

- Brandt, Patrick T. and John R. Freeman. 2006. "Advances in Bayesian Time Series Modeling and the Study of Politics: Theory Testing, Forecasting, and Policy Analysis." *Political Analysis*. 14(1):136.
- Litterman, R.B. 1986. "Forecasting with Bayesian vector autoregressions: Five years of experience" *Journal of Business & Economic Statistics*. 25–38.

- Sims, C.A. and Tao Zha. 1998. "Bayesian Methods for Dynamic Multivariate Models." *International Economic Review*. 39(4):949-968.

- Sims, C.A. and Tao Zha. 1999. "Error Bands for Impulse Responses." *Econometrica* 67(5): 1113–1156.

Supplemental readings / examples:

- Bauwens, L. Lubrano, M and Richard, J.F. 1999 . Bayesian inference in dynamic econometric models. Oxford University Press, USA. Chapters 2-5.

- Gill, Jeff. 2008. Bayesian Methods: A Social and Behavioral Sciences Approach. Chapman & Hall /CRC. Second Edition. Chapter 1-4. (skim)

Week 13 (November 27): Bayesian Simultaneous Equation / Structural Time Series Models This week will cover the basics of Bayesian simultaneous equation models. We will mainly focus on Bayesian structural VAR models, but will also consider other variants.

- Waggoner, Daniel F., and Tao A. Zha. 2003a. "A Gibbs sampler for structural vector autoregressions." *Journal of Economic Dynamics & Control*. 28:349–66.

- Waggoner, Daniel F., and Tao A. Zha. 2003b. "Likelihood preserving normalization in multiple equation models." *Journal of Econometrics*. 114:329–47.

- Sattler, Thomas, Patrick T. Brandt, and John R. Freeman. 2010. "Democratic Accountability in Open Economies" *Quarterly Journal of Political Science*. 5(1): 71–97.

- Brandt, Patrick T. and John R. Freeman. 2009. "Modeling Macro Political Dynamics" *Political Analysis*. 17(2): 113–142.

- Brandt, Patrick T., Michael P. Colaresi and John R. Freeman. 2008. "The Dynamics of Reciprocity, Accountability and Credibility." *Journal of Conflict Resolution*. 52(3): 343-374.

- Brandt, Patrick T. and John R. Freeman. 2006. "Advances in Bayesian Time Series Modeling and the Study of Politics: Theory Testing, Forecasting, and Policy Analysis." *Political Analysis*. 14(1):1–36.

Week 14 (December 4): Changepoint and Regime Switching Time Series Models This week will consider frequentist and Bayesian models with time-varying shifts in parameters. We will start with simple testing frameworks for these models and then build up to fully Bayesian approaches.

- Bai J., Perron P. 1998. "Estimating and Testing Linear Models With Multiple Structural Changes", *Econometrica*, 66, 47-78.

- Bai J., Perron P. 2003. "Computation and Analysis of Multiple Structural Change Models", *Journal of Applied Econometrics*, 18, 1-22.

- Chib, Siddhartha. 1996. "Calculating posterior distributions and model estimates in Markov mixture models." *Journal of Econometrics*. 75: 79-97.

- Chib, Siddhartha. 1998. "Estimation and comparison of multiple change-point models." *Journal of Econometrics*. 86: 221–41.

- Frühwith-Schnatter, Sylvia. 2001. "Markov Chain Monte Carlo Estimation of Classical and Dynamic Switching and Mixture Models" *Journal of the American Statistical Association*. 96(453) 194-209.

Supplemental readings / examples:

- Brandt, Patrick T. and Todd Sandler. 2009. "Hostage Taking: Understanding Terrorism Event Dynamics" *Journal of Policy Modeling*. 31(5): 758–778.

- Brandt, Patrick T. and Todd Sandler. 2010. "What Do Transnational Terrorists Target? Has it Changed? Are We Safer?" *Journal of Conflict Resolution* 54(2): 214–236.

- Enders, Walter and Todd Sandler. 2005. "After 9/11: Is it all different now? Journal of Conflict Resolution". 49(2): 259-77.
- Freeman, J.R. and Hays, J.C. and Stix, H. 2000. "Democracy and markets: The case of exchange rates" *American Journal of Political Science*. 44(3):449-468.
- Hays, J.C. and Freeman, J.R. and Nesseth, H. 2003. "Exchange rate volatility and democratization in emerging market countries". *International Studies Quarterly*. 47(2):203–228.
- Kim, Chang-Jin and Charles Nelson. 1999. *State-Space Models with Regime Switching: Classical and Gibbs-Sampling Approaches with Applications*. MIT Press. Chapters 4 and 9.

Week 15 (December 11): Non-Gaussian time series models This week we will cover what to do when your dependent variable is non-Gaussian. That is, you are dealing with a count, a duration, an interval, or other measure as your time series dependent variable. This is a cutting edge area in many parts of the social, behavioral, and even hard sciences.

- Shumway and Stoffer, Ch 6.
- Cowpertwait and Metcalf, Ch. 12.
- Brandt, Patrick T. and John T. Williams. 2001. "A Linear Poisson Autoregressive Model: The Poisson AR(p)" *Political Analysis*. 9(2):164–184.
- Brandt, Patrick T., John T. Williams, Benjamin O. Fordham, and Brian Pollins. 2000. "Dynamic Modeling for Persistent Event Count Time Series" *American Journal of Political Science*. 44(4):823843.
- Brandt, Patrick T. and Todd Sandler. 2012. "A Bayesian Poisson Vector Autoregression Model" *Political Analysis*. 20(3): 292–315.

Supplemental :

- Congdon, P. 2007. "Bayesian modeling strategies for spatially varying regression coefficients: A multivariate perspective for multiple outcomes." Computational Statistics & Data Analysis 51: 258-301.
- Congdon, R. 2003. *Applied Bayesian Modeling*. John Wiley & Sons.

These descriptions and timelines are subject to change at the discretion of the Professor.