PLCS 505: Time Series Analysis in Political Science

Prof. Linn
Spring 2020
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Office hours: Thursdays 9:00-12:00, and by appointment

Course Description

This course considers statistical techniques to evaluate social processes occurring through time. The course introduces students to time series methods and to the applications of these methods in political science. The early focus is on the descriptive analysis of time series, but we will move quickly to more rigorous univariate time series analysis. In this section of the course we will introduce linear difference equations as the foundation for understanding political dynamics and will develop models for stationary and nonstationary time series. We will consider traditional econometric analyses of time series using regression techniques. We will also look at important topics in time series analysis including Granger causality and vector autoregression, and cointegration techniques. In the final section of the course we will cover pooled time series models. The emphasis throughout the course will be on application, rather than on statistical theory. However, the focus of most lectures will be statistical theory. I expect students to have a firm grounding in probability and regression analysis and to bring to the course some interesting questions about the dynamics of political processes. Homework will revolve as much as possible around the time series you are interested in understanding. To that end, students will need to gather a time serial data set for analysis during the first week of class (this data need not be used for the full term). Longer time series are better than shorter ones,. Ideally the time series with which you work will have at least 200 time points (measured at equally spaced intervals), but consider 100 the minimum.

Software

We will be using *R* and *R* Notebooks for all analysis. *R* isn't as user friendly for time series analysis as for other types of analysis; it does not naturally understand the structure of the data, functions you are used to using for regression for example do not handle lags without additional manipulation of the data, and packages are just being written to handle things many other software packages, like Stata, RATS, or Eviews, handle routinely. Thus, we will spend considerable class time working together in *R*.

Readings

There are 3 required texts for this course. We will be reading a majority of all 3. You may purchase the 3rd or 4th edition of Enders. It is an expensive text but will be a useful resource in the future. I recommend ordering the books online to minimize cost. Articles and chapters will be available online through Penn State Libraries and/or Canvas. I do recommend that you own at least one basic time series text and provide a list of books in my time series library below.

- Enders, Walter. 2015. *Applied Econometric Time Series*, 4th Edition. New York: Wiley. I have a hard copy you may borrow to copy relevant pages.

- Lebo, Matthew and Suzanna Linn. *A Practical Guide to Time Series Analysis.* Draft Chapters.
- Patrick T. Brandt and John T. Williams. 2007. *Multiple Time Series Models.* Sage. This is inexpensive and worth the investment.

Student Evaluation

Your course grade will be based on a set of data analysis assignments (including a detailed application), a final paper and presentation, and course participation. Attendance is required.

1. Roughly weekly data analysis assignments applying the methods covered in the course using your own data (45%).
2. For one of the data analysis assignments, write 3-4 page application to demonstrate either (a) unit root/stationarity tests, (b) dynamic regression analysis with stationary time series data, (c) single equation cointegration analysis, or (d) vector autoregression (10%).
3. Write a final paper addressing a question about political/social dynamics of interest to you that can be answered with the techniques covered in the course. Your data analysis assignments should provide the basic ingredients for your final analysis (20%). Alternatively, you may choose to write a paper on a time series methods question, such as would appear in the *AJPS* Workshop or *Political Analysis.* This option may be appealing to those of you who have a first field in methods or who are pursuing a dual title degree in SODA.
4. Present your paper to class (5%).
5. Final exam (20%).

Academic Integrity

Academic integrity is the pursuit of scholarly activity in an open, honest and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle. Consistent with this expectation, the University?s Code of Conduct states that all students should act with personal integrity, respect other students? dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts.

Academic integrity includes a commitment by all members of the University community not to engage in or tolerate acts of falsification, misrepresentation or deception. Such acts of dishonesty violate the fundamental ethical principles of the University community and compromise the worth of work completed by others.The Department of Political Science, along with the College of the Liberal Arts and the University, takes violations of academic dishonesty seriously. Observing basic honesty in one's work, words, ideas, and actions is a principle to which all members of the community are required to subscribe.

Disability Accommodation Statement

Penn State welcomes students with disabilities into the University?s educational programs. Every Penn State campus has an office for students with disabilities. Student Disability Resources (SDR) website provides contact information for every Penn State campus (http://equity.psu.edu/sdr/disability-coordinator). For further information, please visit the Student Disability Resources website (http://equity.psu.edu/sdr/).

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: See documentation guidelines at (http://equity.psu.edu/sdr/guidelines). If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

Counseling and Psychological Services Statement

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients? cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

Counseling and Psychological Services at University Park (CAPS) `http://studentaffairs.psu.edu/counseling/`: 814-863-0395.

Penn State Crisis Line (24 hours/7 days/week): 877-229-6400.

Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741.

Educational Equity/Report Bias Statement

Penn State takes great pride to foster a diverse and inclusive environment for students, faculty, and staff. Consistent with University Policy AD29, students who believe they have experienced or observed a hate crime, an act of intolerance, discrimination, or harassment that occurs at Penn State are urged to report these incidents as outlined on the University?s Report Bias webpage `http://equity.psu.edu/reportbias/`.

Course Calendar: TENTATIVE

***All readings are to be read BEFORE class with the exception of Week 1.**

Getting Started

Week 1 January 15: Overview, R dates and plots

Required Reading

- Box-Steffensmeier, Janet M., John Freeman, and Jon Pevehouse. 2015. *Time Series For Social Scientists* Cambridge, MA: Cambridge University Press. (TSSS). Chapter 1, "Modeling Social Dynamics."
- "Working with Financial Time Series Data in R." Eric Zivot. `https://faculty.washington.edu/ezivot/econ424/Working%20with%20Time%20Series%20Data%20in%20R.pdf`.
- An overview of packages for time series analysis by Rob Hyndman. `https://cran.r-project.org/web/views/TimeSeries.html`.

Homework #1: Data Collection and visualization. Due Tuesday, January 21 by midnight.

Part 1: Dynamics of Single Time Series

Week 2 January 22: Stationary time series processes – definitions and illustrations in R

Required Reading

- PGTSA, Chapter 2. "Univariate Time Series Models," sections 1 and 2.

Recommended Reading

- TSSS. Chapter 2. "Univariate Time Series Models," sections 2.1 – 2.3.
- Enders, Chapter 1, sections 1-6 and 9. Chapter 2. "Stationary Time Series Models."
- R Help:
  - "An R time series quick fix." This is linked on the web page for Shumway, Robert H. and David S. Stoffer. 2017. *Time Series Analysis and Its Applications with R Examples*, 4th edition. New York: Springer Texts in Statistics at `https://www.stat.pitt.edu/stoffer/tsa4/index.html`. (See the menu at the bottom of the page.)
  - "Some R Time Series Issues": This is linked from the above page at `https://www.stat.pitt.edu/stoffer/tsa4/Rissues.htm`
  - Cowpertwait, Paul S. and Andrew V. Metcalfe. 2009. *Introductory Time Series with R*. New York: Springer Texts in Statistics. Chapter 1.
  - "Using R for Time Series Analysis." *A Little Book of Time Series* by Avril Coghlan. `https://a-little-book-of-r-for-time-series.readthedocs.io/en/latest/src/timeseries.html`.

Homework #2: Model Identification, Estimation and Diagnosis. Due Monday, January 27 by midnight.

Week 3 January 29: Nonstationary time series processes and illustrations in R. Tests part 1

Required Reading

- PGTSA, Chapter 2. "Univariate Time Series Models," sections 3 and 4.
- PGTSA, Chapter 3 "Testing for Unit Root, Stationarity, and Fractionally Integrated Processes" (all).

Recommended Reading

- TSSS. Chapter 5, "Univariate, Non-stationary Processes: Tests and Modeling," section 5.1.
- Enders, Chapter 4 "Models with Trend," sections 1-4.

Homework #3: Testing for unit roots. Due Monday, February 10 by midnight.

Week 4 February 5: Unit root tests Part 2 with illustrations in R

Required Reading

- Enders, Chapter 4 "Models with Trend," sections 5 – 10 and Summary/Conclusions.

Recommended Reading

- TSSS. Chapter 5, "Univariate, Non-stationary Processes: Tests and Modeling," sections 5.2 – end.
- De Boef, Suzanna and Jim Granato. 1997. "Near-Integrated Data and the Analysis of Political Relationships." *American Journal of Political Science* 41(2): 619-640.
- 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.

Part 2: Single Equation Regression Models

Week 5 February 12: Dynamic regression with stationary time series Assumptions and the ADL and ECM with examples in R

Required Reading

- PGTSA, Chapter 5. "Regression Models for Time Series Data." Sections 1-3.
- Keele, Luke and Nathan Kelly. 2006. "Dynamic Models for Dynamic Theories: The Ins and Outs of Lagged Dependent Variables." *Political Analysis*. 14:186-205.

Recomomended Reading:

- TSSS, Chapter 3, "Dynamic Regression Models," section 3.1.

Homework #4: Dynamic Regression. Due Monday, February24 by midnight.

Week 6 February 19: Dynamic regression with stationary time series. A typology with example in R

Required Reading:

- De Boef, Suzanna and Luke Keele. 2008. "Taking Time Seriously." *American Journal of Political Science* 52(1): 184-200.
- Keele, Luke, Suzanna Linn, and Clayton Webb. 2015. "Treating Time with All Due Seriousness." *Political Analysis.*
- Grant, Taylor and Matthew Lebo. 2015. "Error Correction Methods with Political Time Series." *Political Analysis.*

Week 7 February 26: Dynamic regression with nonstationary time series. Cointegration with examples in R

Required Reading:

- PGTSA, Chapter 5. "Regression Models for Time Series Data," sections 4 – end.
- Enders, Chapter 6, "Cointegration and Error-Correction Models," sections 1 – 5.
- Hendry, David.F. and Juselius, Katerina. 2000. "Explaining Cointegration Analysis: Part 1." *The Energy Journal* 1:1-42. `https://ora.ox.ac.uk/objects/uuid:88122282-ba30-40dc-8118-6401d3c01cff/download_file?file_format=pdf&safe_filename=energy2.pdf&type_of_work=Journal+article`

Recommended Reading:

- TSSS, Chapter 6: "Cointegration and Error Correction Models."

Homework #5: Testing for Cointegration. Due Monday, March 2 by midnight.

Week 8 March 4: Dynamic regression when we are uncertain of the dynamic properties of the time series. Estimating long run relationships with examples in R

Required Reading

- PGTSA, Chapter 6. "Regression Models Under Uncertainty about Unit Roots" (all).
- Philips, Andrew Q. 2018. "Have Your Cake and Eat it Too? Cointegration and Dynamic Inference from Autoregressive Distributed Lag Models." *American Journal of Political Science* 62(1):230-244.

Recommended Reading

- Webb, Clayton, Linn, Suzanna, and Lebo, Matthew. 2019. "A Bounds Approach to Inference Using the Long Run Multiplier." *Political Analysis* 27(3):281-301.
- Webb, Clayton, Linn, Suzanna, and Lebo, Matthew. Forthcoming. "Beyond the Unit Root Question: Uncertainty and Inference." *American Journal of Political Science.*

- Giles, David. "ARDL Models - Part II - Bounds Tests" [Blog post]. Retrieved from `https://davegiles.blogspot.com/2013/06/ardl-models-part-ii-bounds-tests.html`.
- Eviews Blog. See especially "Part 3."
  - Eviews. 4/3/2017. "AutoRegressive Distributed Lag (ARDL) Estimation. Part 1 - Theory" [Blog post]. Retrieved from `http://blog.eviews.com/2017/04/autoregressive-distributed-lag-ardl.html`
  - Eviews. 5/8/2017. "AutoRegressive Distributed Lag (ARDL) Estimation. Part 2 - Estimation" [Blog post]. Retrieved from `http://blog.eviews.com/2017/05/autoregressive-distributed-lag-ardl_8.html`
  - Eviews. 5/16/2017. "AutoRegressive Distributed Lag (ARDL) Estimation. Part 3 - Practice" [Blog post]. Retrieved from `http://blog.eviews.com/2017/05/autoregressive-distributed-lag-ardl.html`

Homework #6: Testing for Long-Run Relationships. Due Tuesday, March 17 by midnight.

Week 9 March 11: SPRING BREAK

Part 3: Multivariate Time Series Models

Week 10 March 18: Endogenous time series, Granger causality, VAR with stationary time series with examples in R

Required Reading

- Enders, Chapter 5, "Introduction to VAR Analysis" (pages 297-329).
- Brandt and Williams, Chapters 1-2.
- Granato, Jim and Renee M. Smith. "Exogeneity, Inference and Granger Causality: Part I: The Stationary Case." *The Political Methodologist* 5(2): 24-28. You can find issues of *TPM* on The Political Methodology Society web page at `http://polmeth.wustl.edu/methodologist.php?i=3`.
- Granato, Jim and Renee M. Smith. "Exogeneity, Inference and Granger Causality: Part II: The Case of Integrated Regressors." *The Political Methodologist* 6(1): 23-26.

Recommended Reading

- TSSS, chapter 4, "Modeling the Dynamics of Social Systems," sectionos 4.3 and 4.4.
- Freeman, John. 1983. "Granger Causality and the Time Series Analysis of Political Relationships." *American Journal of Political Science* 27(2): 327-358.

Homework #7: Estimating a VAR. Due Monday, March 30 by midnight.

Week 11 March 25: VAR with stationary time series (continued)

Required Reading:

- Brandt and Williams, Chapter 3.

Week 12 April 1: Cointegrated VAR. Testing for cointegration with examples in R

Required Reading:

- Juselius, K. and Hendry, D.F., 2000. "Explaining Cointegration Analysis: Part 2." (No. 00-20).

Homework #8. Due Monday, April 13 by midnight.

Week 13 April 8: More cointegrated VAR

Late Drop Deadline: Friday, April 10.

Part 4: Pooled Time Series Analysis

Week 14 April 15: Panel models with examples in R

Required Reading

- Cameron, A.C. and Trivedi, P.K., 2005. *Microeconometrics: Methods and Applications*. Cambridge university press. Chapter 21.
- Wooldridge, Jeffrey M. 2010. *Econometric Analysis of Cross Section and Panel Data*, second edition. MIT Press, Chapters 7 and 10. `http://fin.shufe.edu.cn/fe/Books%20&%20Links/Wooldridge%20Econometric%20analysis.pdf`

Recommended Reading

- Stimson, James A. 1985. "Regression in Space and Time: A Statistical Essay" *American Journal of Political Science* 29(4): 914-945.

Homework #9. Pooled Time Series Analysis (I will provide data). Due Monday, April 27 by midnight.

Week 15 April 22: Time Series Cross Section (TSCS) models with examples in R

Required Reading

- Cameron, A.C. and Trivedi, P.K., 2005. *Microeconometrics: Methods and Applications*. Cambridge university press. Chapter 22.
- Beck, Nathaniel and Jonathan N. Katz. 1995. "What to Do (and Not to Do) with Times-Series-Cross-Section Data." *American Political Science Review* 89(3): 634-647.
- Beck, Nathaniel and Jonathan N. Katz. 2011. "Modeling Dynamics in Time-Series-Cross- Section Political Economy Data." *Annual Review of Political Science* 14: 331-352.

Week 16 April 29: Student Presentations

Topical Time Series Bibliography

Temporal Aggregation:

- Freeman, John R. l990. "Systematic Sampling, Temporal Aggregation and the Study of Political Relationships." *Political Analysis* 1.
- Granger, Clive W.J. 1990. "Aggregation of Time-Series Variables: A Survey." *Disaggregation in Econometric Modeling*: 17-34.
- Granger, Clive W.J. and P.R. Sikklos. 1995. "Systematic Sampling, Temporal Aggregation, Seasonal Adjustment, and Cointegration: Theory and Evidence." *Journal of Econometrics* 66: 357-369.
- Robertson, John C. and Ellis W. Tallman. "Data Vintages and Measuring Forecast Model Performance." *Economic Review* Atlanta, GA: Federal Reserve Bank of Atlanta, Fourth Quarter, 1998: 4-20.
- Tiao, G.C. and W. Wei. 1976. "Effect of Temporal Aggregation on the Dynamic Relationship of Two Time Series Variables." *Biometrika* 63(3): 513-523.
- Zellner, A. and C. Montemarquette. l971. "A Study of Some Aspects of Temporal Aggregation Problems in Econometric Analysis." *Review of Economics and Statistics* 53: 335-342.

Univariate Models for Stationary Time Series: Definitions, Estimation

- Mills, Terrence C. and Raphael N. Markellos. 2008. *The Econometric Modeling of Financial Times Series*, 3rd edition. Cambridge: Cambridge University Press. Chapter 2.
- Mills, Terrence C. 1990. *Time Series Techniques for Economists.* Cambridge: Cambridge University Press. Chapters 5, 7-8, and 10. (This covers the same material in Mills and Markellos but more slowly.)
- Shumway and Stoffer. Chapter 3 OR Cryer and Kung-Sik. Chapters 4-6 and 8 (friendly read) for treatment of the material with R code.
- McCleary, Richard and Richard A. Hay, Jr. 1980. *Applied Time Series Analysis for the Social Sciences.* Beverly Hills: Sage. Chapter 2. (This is the original treatment for social scientists and is out of print. I have a hard copy if you would like to make a copy.)
- Hamilton, James D. 1994. *Time Series Analysis.* Princeton, New Jersey: Princeton University Press. Chapters 1-3.

Univariate Models for Non-stationary Time Series: Definitions, Tests

- Banerjee, Anindya, Juan Dolado, J.W. Galbraith, and David F. Hendry. 1993. Co-integration, Error Correction, and the Econometric Analysis of Non-Stationary Data. Oxford: Oxford University Press. Chapters 3 and 4.
- Cromwell, Jeff B., Walter C. Labys, and Michel Terraza. 1994. *Univariate Tests for Time Series Models.* Beverly Hills, CA: Sage, pp. 1-36.
- Pfaff, Bernhard. 2008. *Analysis of Integrated and Cointegrated Time Series with R.* Springer Texts in Statistics, pp. 19-37. Looks clear but leaving.
- Choi, I., 2015. *Almost All about Unit Roots: Foundations, Developments, and Applications.* Cambridge University Press.

- Banerjee, Anindya, Juan Dolado, J.W. Galbraith, and David F. Hendry. 1993. Co-integration, Error Correction, and the Econometric Analysis of Non-Stationary Data. Oxford: Oxford University Press. Chapters 3 and 4.
- Hamilton, James D. 1994. *Time Series Analysis*. Princeton, New Jersey: Princeton University Press, Chapters 15-17.
- Mills, Terrence C. and Raphael N. Markellos. 2008. *The Econometric Modeling of Financial Times Series*, 3rd edition. Cambridge: Cambridge University Press. Chapter 3.
- Cowpertwait, Paul S. and Andrew V. Metcalfe. 2009. *Introductory Time Series with R*. New York: Springer Texts in Statistics. Chapter 7, through section 7.3.
- 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.

Long Memory

- Cowpertwait, Paul S. and Andrew V. Metcalfe. 2009. *Introductory Time Series with R*. New York: Springer Texts in Statistics. Chapter 8, Long Memory Processes.
- De Boef, Suzanna and Jim Granato. 1997. "Near-Integrated Data and the Analysis of Political Relationships." *American Journal of Political Science* 41(2): 619-640.
- 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.
- Lebo, Matthew, Robert W. Walker, and Harold D. Clarke. 2000. "You Must Remember This: Dealing with Long Memory in Political Analyses." *Electoral Studies*, Vol. 19, No. 2. (March): 31-48.
- Box-Steffensmeier, Janet M. and Andrew R. Tomlinson. 2000. "Fractional Integration Methods in Political Science." *Electoral Studies* 19(1): 63-76.

Dynamic Regression – Serial Correlation

- TSSS, chapter 3, "Dynamic Regression Models."
- De Boef, Suzanna and Luke Keele. 2008. "Taking Time Seriously." *American Journal of Political Science* 52(1): 184-200.
- Davidson and MacKinnon (1993), Chapter 10.
- Durbin, J. and G.S. Watson. 1950. "Testing for Serial Correlation in Least Squares Regression I." *Biometrika* 37(3-4): 409-428.
- Durbin, J. and G.S. Watson. 1951. "Testing for Serial Correlation in Least Squares Regression II." *Biometrika* 38(1-2): 159-178.
- Hibbs, Douglas. 1974. "Problems of Statistical Estimation and Causal Inference in Time-Series Regression Models." *Sociological Methodology*. 252-307.
- Jarque, Carlos M. and Anil K. Bera. 1980. "Efficient Tests for Normality, Homoscedasticity, and Serial Independence of Regression Residuals" *Economic Letters* 6(3): 255-259.

Dynamic Regression for Stationary Time Series

- Banerjee, Anindya, Juan Dolado, J.W. Galbraith, and David F. Hendry. 1993. Co-integration, Error Correction, and the Econometric Analysis of Non-Stationary Data. Oxford: Oxford University Press. Chapter 2.
- Granger and Newbold (1986), Chapter 5.
- Hamilton, James (1994). Chapter 8.
- Beck, Nathaniel. 1985. "Estimating Dynamic Models is Not Merely a Matter of Technique." *Political Methodology*. 11:71-89.
- Hendry, David F. and Jean-Francois Richard. 1982. "On the Formulation of Empirical Models in Dynamic Econometrics." *Journal of Econometrics* 20(1): 3-33. On selecting models.
- Hendry, David F. and Jean-Francois Richard. 1983. "The Econometric Analysis of Time Series." *International Statistical Review* 51(2): 111-163. On selecting models.
- Hendry, David F. and Jean-Francois Richard. 1988. "Recent Developments in the Theory of Encompassing." Institute of Statistics and Decision Sciences, Duke University 88-05. On selecting models.

Dynamic Regression for Stationary Time Series – Applications

- Ura, J.D., 2014. "Backlash and Legitimation: Macro Political Responses to Supreme Court Decisions." *American Journal of Political Science* 58(1):10-126.

Single Equation Cointegration —Theory and Tests.

- Banerjee, Anindya, Juan Dolado, J.W. Galbraith, and David F. Hendry. 1993. *Co-integration, Error Correction, and the Econometric Analysis of Non-Stationary Data*. Oxford: Oxford University Press. Chapters 5, 6, and 7.
- Beck, Nathaniel. 1993. "The Methodology of Cointegration." *Political Analysis* 4(1): 237-248.
- Davidson and MacKinnon (1993), Chapter 20.
- De Boef, Suzanna. 2001. "Modeling Equilibrium Relationships: Error Correction Models with Strongly Autoregressive Data." *Political Analysis* 9(1): 78-94.
- Durr, Robert. 1993. "An Essay on Cointegration and Error Correction Models." *Political Analysis* 4: 185-228.
- Durr, Robert. 1993. "Of Forest and Trees." *Political Analysis* 4: 255-258. *Political Research Quarterly* 64(4): 749-764.
- Engle, R.F. and C.W.J. Granger. 1987. "Cointegration and Error Correction: Representation, Estimation, and Testing." *Econometrica* 55(2): 251-276.
- Engle, R.F. and C.W.J. Granger. 1991. *Long Run Economic Relationships: Readings in Cointegration*. New York: Oxford University Press.
- Hall, S.G. 1989. "Maximum Likelihood Estimation of Cointegration Vectors: An Example of the Johansen Procedure." *Oxford Bulletin of Economics and Statistics* 51(2): 213-218.
- Hamilton, James (1994). Chapter 19.

- Mills, Terrence C. and Raphael N. Markellos. 2008. *The Econometric Modeling of Financial Times Series*, 3rd edition. Cambridge: Cambridge University Press. Chapter 9.
- Murray, Michael P. 1994. "A Drunk and Her Dog: An Illustration of Cointegration and Error Correction." *The American Statistician* 48:37-9.
- Smith, Renee. 1993. "Error Correction, Attractors and Cointegration." *Political Analysis* 4(1): 249-254.
- Williams, John. 1992. "What Goes Around Comes Around: Unit Root Tests and Cointegration." *Political Analysis* 4(1): 229-236.

Cointegration Applications

- Ostrom, Charles W, Jr. and Renee Smith. 1992. "Error Correction, Attitude Persistence, and Executive Rewards and Punishments: A Behavioral Theory of Presidential Approval." *Political Analysis* 4(1): 127-183.
- Caldeira, Gregory A. and Christopher J.W. Zorn. 1998. "Of Time and Consensual Norms in the Supreme Court." *American Journal of Political Science* 42(3): 874-902.
- Haber, Stephen and Victor Menaldo. 2011. "Do Natural Resources Fuel Authoritarianism? A Reappraisal of the Resource Curse." *American Political Science Review* 105(1): 1-26.
- Lebo, Matthew J. and Will H. Moore. 2003. "Dynamic Foreign Policy Behavior." *Journal of Conflict Resolution* 47(1): 13-32.
- Adam, Christopher. 1991. "Financial Innovation and the Demand for £M3 in the UK: 1975- 1986." *Oxford Bulletin of Economics and Statistics* 53(4): 401-424.
- Box-Steffensmeier, Janet M. and Andrew R. Tomlinson. 2000. "Fractional Integration Methods in Political Science." *Electoral Studies* 19(1): 63-76.
- Clarke, Harold D. and Marianne C. Stewart. 1994. "Prospections, Retrospections, and Rationality: The 'Bankers' Model of Presidential Approval Reconsidered." *American Journal of Political Science* 38(4): 1104-1123.
- Dickey, David A., Dennis W. Jansen, and Daniel L. Thorton. 1991. "A Primer on Cointegration with an Application to Money and Income." Federal Reserve Bank of St. Louis Review. 73(2): 58-78.
- Durr, Robert. 1993. "An Essay on Cointegration and Error Correction Models." *Political Analysis* 4(1): 185-228.
- Krause, George A. 1997. "Voters, Information Heterogeneity, and the Dynamics of Aggregate Economic Expectations." *American Journal of Political Science* 41(4): 1170-1200.

Cointegrated VAR

- Hall, S.G. 1989. "Maximum Likelihood Estimation of Cointegration Vectors: An Example of the Johansen Procedure." *Oxford Bulletin of Economics and Statistics* 51(2): 213-218.
- Johansen, Soren. 1988. "Statistical Analysis of Cointegration Vectors." Journal of Economic Dynamics and Control 12(2-3): 231-254.
- Juselius, Katerina. 2006. *The Cointegrated VAR Model: Methodology and Applications.* Oxford university press.

Exogeneity

- Engle, Robert F., David F. Hendry, and Jean-Francois Richard. 1983. "Exogeneity."
- Thurman, Walter N. and Mark E. Fisher. 1988. "Chickens, Eggs, and Causality, or Which Came First?" *American Journal of Agricultural Economics* 70(2): 237-238.

Additional Theoretical Treatments of VAR

- Brandt, Patrick T. and John R. Freeman. 2009. "Modeling Macro-Political Dynamics." *Political Analysis* 17(2): 113-142.
- Freeman, John, Daniel Houser, Paul M. Kellstedt, and John T. Williams. 1998. "Long- Memoried Processes, Unit Roots, and Causal Inference in Political Science." *American Journal of Political Science* 42(4): 1289-1327.
- Cromwell, Jeff B., Michael J. Hannan, Walter C. Labys, and Michel Terraza. 1994. *Multivariate Tests for Time Series Models* (Sage University Paper series on Quantitative Applications in the Social Sciences, 07-100). Thousand Oaks, CA: Sage, pages 32-67.
- Mills (1990), pp. 281-305.
- Stock, James H. and Mark W. Watson. 2001. "Vector Autoregressions." *Journal of Economic Perspectives* 15(4): 101-115.
- Geweke, John. 1984. "Inference and Causality in Economic Time Series Models," pages 1101- 1144 in Griliches and Intrilligator (eds.), *Handbook of Econometrics*, Volume 2. Amsterdam: Elsevier.
- Williams, John T. 1992. "Dynamic Change, Specification Uncertainty, and Bayesian Vector Autoregression Analysis." *Political Analysis* 4(1): 97-125.

VAR Applications

- Box-Steffensmeier, Janet M., David Darmofal, and Christian A. Farrell. 2009. "The Aggregate Dynamics of Campaigns." *Journal of Politics* 71(1): 309-323.
- Brandt and Williams, Chapter 3.
- Brandt, Patrick T., Michael Colaresi, and John R. Freeman. 2008. "The Dynamics of Reciprocity, Accountability, and Credibility." *Journal of Conflict Resolution* 52(3): 343- 374.
- Freeman, John T., Tse-min Lin, and John Williams. 1989. "Vector Autoregression and the Study of Politics." *American Journal of Political Science* 33(4): 842-877.
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Texts for your Time Series Library

Springer has published several texts for time series analysis. **All** of these are available for free download through Penn State Libraries from Springer.

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