

University of Southern California
MSc in Applied Economics and Econometrics

Course and Contact Information

Course: Econ 515 Time Series Analysis

Semester: Spring 2025

Number of Units: 4

Course Location: KAP 144

Instructor and Contact information

Ratika Narag, PhD

Office: KAP 360

Office hours: Mondays 11:30 am-12:30 pm KAP 360 or by appointment

Email: narag@usc.edu

Teaching Assistant: TBA

Course Objectives:

The objective of this course is to give students the tools required to understand and implement models commonly used in time series econometrics. Most data in macroeconomics and finance come in the form of time series—a set of repeated observations of the same variable, such as GDP or a stock return. Time series forecasts are used in a wide range of economic activities, including setting monetary and fiscal policies, state and local budgeting, financial management, and financial engineering. Monitoring macroeconomic conditions in real time is inherently a big data problem. It crucially relies on the availability and the exploitation of a large amount of complex data. Increasing complexity of the data leads to increasing complexity in the models, with a growing number of parameters to estimate. Dealing with large data sets using overly simplified models may lead to misspecification as important features are omitted. On the other hand, modeling the interaction among a large number of variables leads to a proliferation of parameters.

In this course, we will learn how to deal with this issue of model selection in timeseries data and emphasis will be placed on intuition and application. The course will both help students understand how to use time series data to test hypotheses and serve as an introduction to the ideas and techniques of forecasting. To gain a deeper understanding of how the methods work, we will also spend a considerable amount of class time discussing their mathematical/statistical underpinnings. The aim of this course is to make you proficient in mathematical and statistical modeling of time series data.

Topics covered include time series properties of data (unit roots, near unit roots, stationarity), difference equations, stationary models (autoregressive and moving-average models), models with trends (deterministic and stochastic), multi-equation models (reduced-form and structural VARs), cointegration and error-correction models, models with time-varying coefficients, forecasting models, volatility models (conditional heteroscedasticity, ARCH/GARCH, Fractional IGARCH models) and basic forecast evaluation. Students will become proficient with performing basic time series analysis and forecasting using time series statistical software. We will review examples of time series techniques applied to problems in macroeconomics, finance, and energy economics.

Course Prerequisites:

Students are expected to be familiar with basic statistical and econometric concepts.

Textbook and Readings: The primary text is Applied Econometric Time Series (Wiley) by Walter Enders. For additional reference texts, please consult: Time Series Analysis, James Hamilton, Cambridge, MA: The MIT Press and Time Series Analysis: Theory and Methods, P. Brockwell and R. Davis, 1991, Springer-Verlag. For those interested in financial time series, please refer to Tsay, R. S., 2005, Analysis of Financial Time Series, Wiley-Interscience. For a background reading in statistics, I recommend The Elements of Statistical Learning by Trevor Hastie, Robert Tibshirani and Jerome Friedman.

Learning Outcomes:

As a result of completing this course, students will be able to: 1. Understand time series data, test for stationarity or trends. 2. Perform and evaluate hypothesis tests and other statistical methods for time series analysis including VARs, and regression analysis of time series data. 3. Understand some of the practical issues in the forecasting of key financial market variables, such as asset prices, risk and dependence and recognize the limitations and assumptions underlying statistical methods 4. Evaluate forecasts and test different forecast models.

Grading:

- Problem Sets 30%
- Research Paper 35%
- Research Paper Presentation 35%

Each problem set will have a due date. Please email or hand in the problem sets to the TA by the due date.

Final grades represent how you perform in the class relative to other students. Your grade will not be based on a mandated target, but on your performance. Three items are considered when assigning final grades:

1. Your average weighted score as a percentage of the available points for all assignments (the points you receive divided by the number of points possible).
2. The overall average percentage score within the class.
3. Your ranking among all students in the class.

Research Paper and Presentation: Graduate-level economics study is designed to prepare you to not just be a more advanced consumer, but also a producer of research and analysis. To that end it is important to practice the research process: identifying a problem, gathering and analyzing data, and communicating your results. Students will write a short original research paper to be presented in class. Students will be graded on the research proposal, the final version of the paper, the presentation of the research paper, and on how well you answer questions posed by your classmates and instructor. Students are encouraged to ask thoughtful questions during paper presentations.

The goal of the paper and presentation is for you to apply the tools you have developed in this class to address an economic question involving time series data. You likely have a topic from your professional or personal life that lends itself to time series analysis, and I encourage you to choose a topic that is familiar and of interest to you. Papers should be well-written and be no longer than 10 pages excluding references. The research proposal is a few paragraphs that poses the research question and answers the

who/what/where/when/why of the research project. The instructor will be happy to advise you on your research question. Presentations will take place in class in the last three weeks of the semester and possibly during the scheduled final exam time, if needed. Please employ a consistent and professional format for your paper (the guidelines in *The Journal of Economic Perspectives* for preparing your tables, charts, and references is a good reference).

Due to the size of the class, you will be presenting in groups of 3. I will email you your group selection by end of week 3. You should plan to meet (virtually or in person) with your team and come up with a research proposal. You should get approval for your topic from the instructor by end of week 7. There will be lab sessions with the TA during the semester. You will be applying the tools learnt in the course to data using software in these sessions. I prefer students to use Python or R as these are fairly simple programming languages to learn and use with time series data. I will email you the dates of these sessions in the first 2 weeks.

Academic Accommodations: Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me as early as possible in the semester. DSP is located in STU 301, and is open 8.30am-5.00pm, Monday through Friday. The phone number for DSP is (213)-740-0776.

Academic Integrity Policy: We are committed to upholding the University's Academic Integrity code as detailed in the Campus Guide. It is the policy of the Economics Department to report all violations of the code. Any serious violation or pattern of violations of the Academic Integrity Code will result in the student's expulsion from the major or minor, or from the graduate program.

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Students are expected to comply with all aspects of USC's **COVID-19 policy**. Failure to do so may result in removal from the class and referral to Student Judicial Affairs and Community Standards.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call studenthealth.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call studenthealth.usc.edu/sexual-assault Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 | Title IX – (213) 821-8298 equity.usc.edu, titleix.usc.edu

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298 usc-advocate.symlicity.com/care_report

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity | Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776 dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Campus Support and Intervention - (213) 821-4710 campussupport.usc.edu

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101 diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call dps.usc.edu

Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC) ombuds.usc.edu

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Course Outline (Tentative):

1. Prerequisite Review: Difference Equations

- (a) Homogenous Difference equations, finding particular solutions for Deterministic Processes.
- (b) Method of Undetermined Coefficients

2. Stationary Models/ Univariate Times Series (stationary).
 - (a) Stochastic Difference equation models
 - (b) Autoregressive processes (AR).
 - (c) Moving average processes (MA).
 - (d) Autoregressive moving average processes (ARMA).

3. Multivariate Time Series.
 - (a) Vector autoregressive processes (VAR). Sims (1980), Stock & Watson (2001).

4. Unit Roots and Cointegration.
 - (a) Univariate. Stock (1994).
 - (b) Multivariate. Engle & Granger (1987), Johansen (1991), Watson (1994).
 - (c) Granger's representation theorem. Hansen (2005a)
 - (d) Structural changes and unit roots. Perron (1989, 1990).

5. Forecasting.
 - (a) Combination: Bates & Granger (1969).
 - (b) Macro forecasting: Stock & Watson (1999), Stock & Watson (2002a), Stock & Watson (2002b)
 - (c) Makridakis et al: Statistical, Machine Learning and Deep Learning Forecasting Methods: Comparisons and Ways Forward (August 2022)
 - (d) Kang et al: Visualizing forecasting algorithm performance using time series instant spaces (International Journal of Forecasting, (2017)
 - (e) Thiyanga S Talagala, Rob J Hyndman, George Athanasopoulos, Meta-learning how to forecast time series, Working Paper, Dec 2022.

6. Volatility Models and Realized Variance (RV).
 - (a) ARCH/GARCH. Engle (1982), Bollerslev (1986).
 - (b) RV Defined and used for Prediction. Andersen & Bollerslev (1998), Andersen, Bollerslev & Meddahi (2004).
 - (c) RV Distribution/Accuracy. Andersen, Bollerslev, Diebold & Labys (2000), Andersen, Bollerslev, Diebold & Ebens (2001), Andersen, Bollerslev, Diebold & Labys (2001), Barndorff-Nielsen & Shephard (2002).
 - (d) Macro Applications. Andersen, Bollerslev, Diebold & Vega (2003).
 - (e) RV and Market Microstructure Noise. Hansen & Lunde (2006), Zhang, Mykland & Ait-Sahalia (2005), Barndorff-Nielsen, Hansen, Lunde & Shephard (2004).

Additional Readings:

Cointegration

Granger, C. W. J., and P. Newbold. 1974. "Spurious Regressions in Econometrics." *Journal of Econometrics* 2 (2): 111–20.

Forecasting:

Elliott, Graham, and Allan Timmermann. 2008. "Economic Forecasting." *Journal of Economic Literature* 46 (1): 3–56.

Campbell, J., A. Lo and C. MacKinlay, 1993, "Chapter 2: Predictability of Asset Returns" in *The Econometrics of Financial Markets*.

Application to Economics:

Hamilton, James D. 1983. "Oil and the Macroeconomy since World War II." *Journal of Political Economy* 91 (2): 228–48.

Nelson, Charles R., and Charles R. Plosser. 1982. "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications." *Journal of Monetary Economics* 10 (2): 139–62. Perron, Pierre, and Tatsuma Wada. 2009. "Let's Take a Break: Trends and Cycles in US Real GDP." *Journal of Monetary Economics* 56 (6): 749–65. Borovkova, Svetlana, and Helyette Geman. 2006. "Seasonal and Stochastic Effects in Commodity Forward Curves." *Review of Derivatives Research* 9 (2): 167–86.