Harvard's
Stat 242 and Econ 2142: Time Series
Fall 2024

Time series centers around three main goals: *describing* data (e.g. seasonal adjustment, detrending), *predicting* future variables given the past data, and *drawing causal* conclusions about the effect of changing one variable on the future path of another. We will delve into principles and methods for all three of these goals. Due to the complexity of these problems, a three-pronged approach is often needed, combining *theory*, *simulation*, and *data*. Throughout problems from economics and finance will be used to illustrate time series methods. Likely topics covered include: martingales, Brownian motion, stochastic integration; theory of prediction; linear models and projection; causality (e.g. SVAR, local projection, control); hidden Markov models, filtering and smoothing; stationarity, non-stationarity; stochastic volatility and high frequency analysis.

Professor: Neil Shephard (shephard@fas.harvard.edu). Office: Science Center 316.01.

Teaching Fellow: .

Lectures: ??. The lectures will not to be recorded. I will post lecture latex notes, but write on the board during lectures with some projected pictures.

Sections and Office Hours: There will be fortnightly sections and weekly office hours. Neil Shephard: ??, 316.1, Science Center.

Course Webpage: https://canvas.harvard.edu/courses/137350 [there is a single website for both Stat 242 and Econ 2142]

References: The lectures notes were written by Neil Shephard. Please read the lecture notes! These will be provided in PDF format; there is no need to purchase any books for the course.

Prerequisites: Stat 110 and Stat 111 (or equivalent) are the main prerequisites, (the lecture notes lists the results from probability and statistics that are used in Stat 111). Multivariable variable calculus plus linear algebra will be needed extensively.

Computing: Some homework problems will require coding to run simulations and/or do statistical computations. I recommend using one of R language via the RStudio interface, Python or Julia.

Grading: Grades will be based on a weighted average of scores from homework and a final exam during final exams week (date TBD).

Let h and f be your homework average and final exam score, respectively, each scaled out of 100. Then your overall score for the course is given by

$$s = \max(0.7 \cdot h + 0.3 \cdot f,\ \ 0.3 \cdot h + 0.7 \cdot f).$$

This course is taken for a letter grade but can also be taken sat/unsat (not pass/fail).

Homework: Since actively solving problems is crucial in learning econometrics and statistics, there will be five problem sets. These will be a mixture of theory, simulation and empirical work.

Homeworks are due on **Fridays at 5:00 pm**. Homework **must** be submitted via the Canvas course website; no submissions on paper or by email will be accepted. Your submission must be a **single** PDF file, no more than 20 MB in size (the size limit is because very large PDFs sometimes

bog down the Canvas grading system), except that computer code can be uploaded in a separate supplementary file if that is more convenient for you (i.e., a .R or .Rmd file with your R code). The *outputs* from your code, e.g., plots and summary statistics, should still be in your main PDF file. Unless otherwise specified, please show your work, simplify fully, and give clear, careful justifications for your answers (using *words and sentences* to explain your logic, in addition to the relevant mathematical expressions and/or code). Your homework can be typeset, written using a tablet, or scanned from handwritten work on paper, but must be clear, easily legible (not blurry or faint), and correctly rotated. Always *check your submission*: download it after uploading it in Canvas, and make sure that it is the correct file, that it meets the above requirements, that it includes all the work you want to be graded, and that it got uploaded successfully.

To help with various circumstances (expected or unexpected), your lowest **two** homework scores will be dropped. Additionally, you can have **two** extensions until Monday at 5:00 pm (the Monday of the week after the Friday deadline). No further extensions will be granted.

You do *not* need to explicitly request to drop a homework or get a Monday extension; both are automatic. Homework is normally due Fridays at 5:00 pm (Eastern). There is a 15 minute grace period, after which a Monday extension will be applied to a submission (automatically and with no penalty), if you have not already used three Monday extensions.

You can submit your homework as many times as you want; the *last* submission will be the one that is graded. For example, if you submit your homework on Friday at 4:59 pm but realize over the weekend that you made a mistake on one of the problems, you can submit a new version by Monday at 5:00 pm (if you still have a Monday extension available).

Homework Collaboration Policy: You are welcome to discuss homework problems with others, but *you must write up your solutions yourself and in your own words*. For problems where coding is required, you must write and run your own code. Additionally, you must list the names of the students with whom you collaborated (if any). Copying someone else's solution, or just making trivial changes for the sake of not copying verbatim, is not acceptable. We highly recommend starting problem sets early enough so that you have time to work hard on the problems on your own first, before discussing them with friends/collaborators. But in any case, your solutions must reflect your own understanding of the material, explained in your own way.

If you used a large language model (e.g. ChatGPT) to help with your coding or theoretical work detail how in your homework script.

Final Exam: The final exam, which will take place during exam week, is a 3 hour closed book test. The exact time and place of the exam is determined by the Registrar.

Discussion Forum: We will use Ed for online discussions; I will tell you when it is setup. Ed can be used for questions and discussions about the homework, and material from class, sections, and the notes. Ed can also be used for meeting people in the class, finding study groups, seeing section and office hour announcements, and various logistical and social conversations. See this link for a quick overview.

When discussing homework questions on Ed, please avoid posting large portions of your solution. General discussions of the relevant concepts and strategies for approaching a problem are fine, as are questions meant to help you get unstuck with a particular step in a solution. If you would like to post a major part of your work as part of a question, you can make the post private (in which case it will only be visible to the teaching staff), but please do that sparingly so that the whole class can benefit as much as possible from the discussions. Also, please *search* before posting a question (someone may have already asked a similar question, in which case it is usually better to

continue that thread than to start a new thread), and when you start a new thread use the correct category (there is a designated category for each homework problem, e.g., HW 2.3 is for Problem 3 of Homework 2) and include a short description of your question in the title.

Please set your Canvas and Ed *notifications* carefully according to your preferences. See here for information about Canvas notifications. In Ed, click the Account button (on the upper right) and go to Settings; also, click the Watch button on threads that you want to stay notified about.

Acknowledgement: The wording in this syllabus and the structure of this course's rules have substantial overlap with the Stat 111 syllabus and course rules, and so some of it reflects the writing of Professor Joe Blitzstein who I teach Stat 111 with.

Additional texts:

Brockwell, Peter J and Richard A Davis (2016) Introduction to Time Series and Forecasting, Springer

Brockwell, Peter J and Richard A Davis (1991) Time Series: Theory and Methods, Springer

Cochrane, John H. (2005) Time Series for Macroeconomics and Finance, unpublished lecture notes

Durbin, James and Siem Jan Koopman (2012) Time Series Analysis by State Space Methods, Oxford University Press

Hamilton, James D (1994) Time Series Analysis, Princeton University Press

Hansen, Lars Peter and Thomas J Sargent (2022) Risk, Uncertainty and Value, unpublished lecture notes

Mikusheva, Anna (2020) Time Series Analysis, unpublished lecture notes

Pena, Daniel and Ruey S Tsay (2022) Statistical Learning for Big Dependent Data, Wiley

Shumway, Robert H and David S Stoffer (2016) Time Series Analysis and Its Applications, Springer

Subba Rao, Suhasini (2022) A Course in Time Series Analysis, unpublished lecture notes