Econ 4310: Macroeconometric Techniques and Applications

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Scheduled Class Time and Organization: Lectures will take place on *Tuesdays* and *Thursdays* from 1:45p-3:15p in PCPE 202.

Course Description: This course will teach you modern econometric techniques that are used to conduct empirical research in macroeconomics and forecast macroeconomic (and, to some extent, financial) time series. Autoregressive models will play an important role in this course. We will also consider state-space models and dynamic stochastic general equilibrium (DSGE) models. Examples of applications include nowcasting and forecasting of inflation and GDP growth, and the analysis of the effects of unanticipated changes in monetary and fiscal policy using structural vector autoregressions and linear projections.

Prerequisites: The prerequisite for this course is Econ 2310 (formerly Econ 104 "Introduction to Econometrics") or the explicit permission of the instructor. To do well in this course you will need to be comfortable with the analysis and application of econometric methods typically covered in Econ 2310, though no specific knowledge of time series econometrics is required. You also need to be comfortable writing R scripts to execute the econometric analysis. Lectures, homework assignments, and the term project will involve substantial amounts of programming and/or data analysis with R.

Courseware: You can access the course materials via CANVAS. You can log-in from *http://upenn.instructure.com/*. On CANVAS you will find all course announcements, lecture notes, reading assignments, problem sets, exam information, etc. We will also use the discussion forum *Ed Discussion* which is available through CANVAS as a plug-in. The discussion board will be the best place to ask any questions you have about course material or logistics. By asking your question and getting an answer on the discussion board, you create a positive externality: other students benefit from your questions and you benefit from theirs. The instructor and teaching assistant will actively moderate the discussions. As an incentive you will received up to 5% credit toward your final grade (see below).

Course Text: There is no required textbook for this course. I will post the lecture slides and recommended readings for each lecture on CANVAS. Having said that, a standard undergraduate econometrics textbook such as the one by James Stock and Mark Watson titled "Introduction to Econometrics" can serve as a useful reference.

Statistical Software: We will use the statistical package *R* via a front-end called RStudio throughout the course. Both programs are free and open source (see CANVAS for how to download and install R and RStudio). It is assumed that you have some familiarity with R from the course(s) that you have taken to satisfy the prerequisites.

Course Requirements and Grading: You are expected to attend the lectures. The overall course grade is based on your participation in the discussion forum, your performance on the in-class quizzes, the problem sets, the exams, and the quality of the term paper.

- **Ed Discussion Participation [5%]**: You will earn participation credit based on the frequency and quality of your contributions to the discussion board. Contributions include questions, answers, and follow-ups. If you participate actively, you will receive full credit. You must contribute to earn points, but spamming the board with clearly unhelpful contributions will not gain you credit.

- **Class Participation and Quizzes [10%]**: During many of the classes, you will write and run short snippets of code to conduct some R calculations related to the lecture material. Each code will produce a numerical answer to a quiz question that you can then enter into CANVAS during the class. We will discuss the answers subsequently in class. On each quiz, you will either receive a one (correct answer) or zero (incorrect answer). I will drop 20% of your lowest scores and compute the quiz score based on the remaining 80%.

Table 1: Assignment Submission Schedule

Assignment	Date Posted	Due Date
Problem Set 1	Th 01/19	Th 01/26
Problem Set 2	Th 01/26	Th 02/02
Problem Set 3	Th 02/02	Th 02/09
Midterm 1 on Tu 02/14		
Problem Set 4	Th 02/16	Th 02/23
Problem Set 5	Th 02/23	Th 03/02
Problem Set 6	Th 03/02	Th 03/16
Problem Set 7	Th 03/16	Th 03/23
Midterm 2 on Tu 03/28		
Term Paper	Th 03/30	Tu 04/25

- **Problem Sets [15%]**: There will be seven problem sets, assigned during the semester (see Table 1 for schedule). The problem sets are designed to give you the opportunity to review and enhance the material learned in class. Solutions must be submitted electronically on the specified due dates (see below for further details) by 11:59pm. Each problem set will be graded on a scale from 0 to 10. Late submissions are penalized with -1 point per day (weekend days and holidays count as well). The four problem sets with the highest scores count toward the grade. No excuses for missed assignments/deadlines will be accepted.
- **Midterm Exam 1 [25%]**: *Tuesday 02/14*, closed books and notes, in class.
- **Midterm Exam 2 [25%]**: *Tuesday 03/28*, closed books and notes, in class.
- **Term Paper (Group Project) [20%]**: this problem involves a replication of an existing study or the application of time series techniques covered in the course to a new data set. Specific instructions will be posted in due time. The final report is due on *Tuesday 04/25*. The group size is restricted to two students.

Your scores on the various assignments will be aggregated at the end of the semester and converted into a letter grade. I will not assign letter grades to individual assignments.

Course Absence Reporting: You must use the Course Absence Reporting (CAR) system to communicate with me (and the College) about absences, in particular during exams and submission dates.

Missed Midterm Exams: If you do not have a valid excuse for missing an exam you will receive a score of zero.

If you do have a valid excuse (see departmental course policies below) for missing a midterm, then the grading proceeds as follows:

- If you miss Midterm 1, then Midterm 2 will count 50%.
- If you miss Midterm 2, then you will have to take a make-up exam in the week of April 17-21. The make-up exam will count 25%. There will only be one make-up exam date for all the students who miss Midterm 2. The make-up exam will also cover materials taught after 03/28.
- If you miss both midterms, then you also will have to take a make-up exam in the week of April 17-21. The make-up exam will count 40% (meaning that you will loose 10 percentage points of the potential exam credit).

Departmental Course Policies: All course policies of the Economics Department apply to Econ 4310 even if not explicitly listed on this syllabus. See:
https://economics.sas.upenn.edu/undergraduate/course-information/course-policies
for full details.

Course Outline

Introduction to time series analysis: downloading and plotting time series from the FRED database; basic transformations (logs and temporal differences); trends and serial correlation; real-time data and data revisions.

The first-order autoregressive model: data simulation; OLS estimation; theoretical properties; generating and evaluating point forecasts; in-sample versus out-of-sample forecasting; simulating trajectories from the predictive density; generating and evaluating interval and density forecasts.

Introduction to Bayesian inference: discrete version of Bayes Theorem; likelihood, prior, and posterior in a binomial model; likelihood, prior, and posterior in the AR(1) model with discretized parameters; conjugate prior and posterior in linear Gaussian regression model; direct sampling; Bayesian forecasting and predictive checks.

Trends and cycles: linear deterministic trend model; stochastic trends; fluctuations around trends.

Higher-order autoregressive models: estimation and theoretical properties; lag length selection; hierarchical modeling and hyperparameter selection.

ARIMA models: Properties; special cases; estimation;

Reduced-form vector autoregressions: theoretical properties; OLS estimation; forecasting; iterative forecasting versus direct estimation; Granger causality; regularized estimation through prior distributions, Minnesota prior.

Structural vector autoregressions: identification via recursive ordering; impulse responses; identification via external instruments; linear projections.

State-space models: an unobserved component model; Kalman filtering; estimation; applications; stochastic volatility.

Other topics (time permitting): factor models; dynamic stochastic general equilibrium models.