Economics 460

Time Series Analysis

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Course Information:
Eco 460 (graduate)
Eco 360(undergraduate)
Spring 2019
MW 2:35-4pm
Location: TBA

Course Description

This course provides an introduction to time series analysis as it is applied in macroeconomics and finance. The class will emphasize hands-on implementation of macroeconometric and time series models for macroeconomic, financial, and policy analysis. Topics include macroeconomic data, linear and nonlinear univariate time series models, practical issues with likelihood-based inference in time series models, forecasting, multivariate models, and structural identification in multivariate models. Each broad topic will include a short case study assignment that will illustrate how to apply the methods covered in class. The class is an elective course for PhD and MS students in economics.

Eco 360 is an elective course for economics majors that counts towards the major requirement. The prerequisites for undergraduate students are Eco 245 or instructor permission. Eco 360 counts towards the Business Analytics Certificate Credit Requirements.

MS & PhD students: you will have additional coding exercises.

PhD students: you will have additional assigned readings and additional coding exercises. In addition, your final project assignment will need to include a more extensive literature review and cannot be limited to reproducing an existing paper. The details will be clearly indicated on each assignment. Please see me the first week of class for clarifications.

Course Objectives

This class has six broad objectives.

1. The students will become familiar with macroeconomic and financial data (Business Analytics LO)
2. The students will learn how to use both standard and cutting edge econometric methods to analyze macroeconomic and time series data. (CBE L.O. 2.1)
3. The students will learn how to use different programming languages for data analyis; I will primarily use R, but will also provide template code for Matlab and Gauss (Business Analytics LO)
4. The students will improve their ability to analyze macroeconomic, financial, and industry-level data and evaluate the plausibility of different models used for forecasting. (LO 6.2)
5. Students will improve their ability to communicate their ideas in writing through completing a final project and writing evaluation reports for their peer's projects This will require collecting, analyzing, and visualizing data. All students will be required to present their research project (LO 3.1)
6. (Graduate only) The students will be introduced to the workhorse models used in empirical macroeconomics and the forecasting literature (this class is a prerequisite for the Advanced Macro class)

Prerequisites

Graduate students: the prerequisites are automatically covered
Undergraduate students: Eco 245 or instructor permission.

I will assume some familiarity with matrix algebra and introductory statistics and econometrics, as well as some basic knowledge of macroeconomics. Also, some prior knowledge in using statistical software or programming will be handy, although all the programming relevant for this course will be covered in class. You will need access to Excel or a similar spreadsheet program, and to Eviews (a "canned" econometrics package that is widely used for time series analysis). However, implementation of some of the methods requires programming. For this, we will use R, a free open source language. If you are already comfortable using another programming language, such as Matlab, you can also use that. I can only promise to provide template code in R, but I do have some template scripts in Matlab, Gauss (Ox), Stata, and RATs. The "light" student versions of Eviews is available for free, and the full student version is available for around $49 (Eviews University Edition).

You will need to use an .edu email to purchase the University Edition of Eviews.

We will discuss how to access Eviews in class, and I will also provide some guidance of programming in class.

Readings and Textbooks

Readings and assignments will be posted on course site.
Because the methods applied in econometrics are constantly changing, there is no single textbook that is able to serve as a reference for all of the material we will discuss in the course. Instead, the lectures will collect together some readings (listed in the course schedule) from journal articles and chapters in textbooks. A lot of the lectures will also cover hands-on implementation of the methodology in Eviews or R.

Some of the readings listed below the topics are the "classic" papers that are referenced by all contemporary papers and that you need to at least skim through. These papers are the basis for the "canned" procedures that are readily available in Eviews, STATA, R, Matlab, etc. It is important that you have at least some idea what the built-in procedures do, especially if you want to write your research paper on that topic. Some of the other readings are recent working papers that use the models covered in class. While you definitely do not have to use the list I provided for your final project, if you use the suggested reading list I can help you by providing code and/or data that you can use as a template (but you will still need to at least skim the classic papers). Once you've selected your topic, contact me for an extended reading list and for the suggested order in which you should read the papers.

Meanwhile, there are two recommend (but not required) textbooks that provide a useful reference for the time series econometric theory needed in the course.

- (Suggested purchase) Applied Econometric Time Series, by Walter Enders. I will use the chapter numbers from the last edition, but any edition is fine. You can buy the older editions for about $20 on Amazon, and I highly recommend buying it.

- (Nice to have but definitely not necessary) Time Series Analysis, by James D. Hamilton, 1994 Recommended for PhD students who declared macroeconomics as a field, not required for undergraduates. It's a good reference book for a lot of the classical approaches that are built into programs such as Eviews and Stata, but it is an older book that does not include a lot of newer developments. You can borrow my copy or use the library copy if you want to decide whether you want to buy it or not.

Keep in mind that these are reference books: they are good to look things up, but I will not be using them as textbooks in the conventional sense of the word. I also find the following textbooks very useful for anyone doing any kind of empirical econometrics (macro or micro):

- Stock and Watson, Introduction to Econometrics (any edition, advanced undergraduate level)
- Angrist and Pischke, "Mostly Harmless Econometrics" (any edition, excellent reference book).

Assignments and Grading

The grading scheme is as follows:

- Class participation 5% (Not missing more than 3 lectures without an excuse=3%; Participating in class discussions and asking questions during presentations+ Helping your classmates out with the assignments by participating in the course site discussion=2%). Every absence after the third one will reduce your overall grade by 1%. If you need to miss class because of a job interview, conference, varsity event, etc, please let me know.
- Final project 15% (first draft+final draft, only final draft is graded, but you will get feedback on the first draft)
- One to two-page referee report 10%
- One-page reply to referee report 5%
- Presentation (or group presentation) 15%
- Homework Assignments 50%

There will be a homework assignment due most weeks, and a final project. Each student will also need to present their final project, write a referee report for a classmate's final project, and a reply to the referee report. You will not need to make changes to your final paper to reply to your classmate's comments, you will just need write up an outline of your reply to the “referee”. The projects may not be fully done by the time you have to referee them. This means that you will have to criticize ideas, methodology, and economic relevance of the proposal, not results (or people).

The assignments will require the use of econometrics software. Many methods can be implemented in Eviews. Some of the methods will require basic knowledge of R (or Matlab, Gauss, Python, or similar programming language). Due to the nature of the course material and the need to use econometric software, the final exam will be a take-home project.

The students will have to present a preliminary draft of their final project in class. The final project will be an Economics Letters-type paper (2000 words, approximately 3-10 pages depending on the number of graphs and tables). In your final project you will need to use one of the methods you learned in class and that at very minimum extends the sample size for an existing key paper.

I encourage students to work together, and the final project can be coauthored by two students. However, for all homework assignments, you must write up your own answers in your own words. The homework assignments cannot be coauthored. Evidence of copying on written work will be treated as a serious breach of academic integrity.

In terms of the presentations, depending on your project and the timing of the presentation, your presentation will include

- the results of the paper that you use as your motivation or the data that you use for your case study
  - why it is important to look at this topic
  - what is original about your project, or what would make your analysis appealing to businesses,
  - what methodology is used
  - what are the main results

- how you plan to extend the paper or use the data set you have
  - If you're writing a more academic paper, for example, you could update the data sample, apply the methodology to another country or another data set
  - If you are using case study data, what business problem will you be solving
- summary statistics for your data set (graphs, means/correlations/etc as appropriate)
- preliminary results (depending on the time of the semester when you present)

The assignments need to be turned in through course site by 5pm on the day they are due.

Assignment grading: Because this might be your first exposure to macroeconomic data and programming, the homework assignments will be graded as check +, check , check -.

- A check + means that you got all or almost of the assignment right, and there are only very minor issues. A check + is equal to 100% and indicates high quality work that is publishable and/or reliable, does not have mathematical errors or coding issues, and the results are correct.
- A check means that there were multiple errors on your assignment, and is equal to 80%.

- A check – means that there are multiple serious errors on your assignment (you used the wrong data set, the wrong methodology, skipped multiple parts of the assignment). A check – is equal to 60%.

- All missed assignments will get a zero score.

- Assignments that are turned in late without arranging an extension will be subject to a 20% per day late submission penalty.

Referee report: The referee report and the reply will also be graded using the check +,- system.

- A check + on the referee report means that you provided at least one thoughtful comment about a potential weakness in your classmate's paper, and at least one suggestion how to deal with this weakness. Because the paper you referee may not be complete when you read it, you will need to find one weak point or one part of the paper can needs work, and make one feasible suggestion to improve it. You can also make comments related to the background results from the original paper, if your classmate(s) are writing an academic research paper.

- A check means that you misunderstood parts of the paper or the methodology, but still made an earnest effort and provided a through and carefully written referee report.

- A check – means that the report was an absolute mess and that you did not make any effort to read the paper at all, or that you made petty mean comments without making any objective suggestions for improvement.

Reply to the referee report The reply to the referee report and my report (single document) should outline how you addressed the criticism that your classmates and I brought up, and it should include a detailed list of all the changes you made, or a brief explanation why you did not make a change. This is a list that tracks the changes you made between the first draft and the final draft and explains why you made those changes (because your referee asked you to do them, because I asked you to do them, or because you filled in gaps in the paper as the paper evolved naturally)

- A check + on the reply means that you: appropriately thanked your referee for helping you improve your paper, provided a list of all the changes you made to deal with their comments, or an outline of how you can deal with their comments
  - for example, if they say "You should include 2016 in your data and you have a typo on page 6" you should say "The new data set includes 2016 and I fixed the typo".
  - If they give you suggestion that is on point, but beyond the scope of your paper, such as adding a lot more data and essentially writing a new paper, you should explain why you're not dealing with their suggestion. For example, if they say "Your paper is too narrow because you only use U.S. data and it can be improved by looking at more countries.". If your original plan was to conduct multi-country analysis and you simply did not have time to include it in your preliminary draft, your reply can be "I extended my analysis to Canada and Mexico". If there is no data for Canada and Mexico you can say "There is no data available for other countries,

but even though my analysis is narrow, this issue is still relevant for policy, see Yellen's statement from October 2015."
    - You don't actually have to do everything the referees and I tell you to do, but you have to justify why you decided not to do something.

- A check means that your report was poorly written or overly defensive, or you did not include an outline of your changes.
- A check – means that you did not reply to the comments and did not include a list with proposed changes

Project grading: Your final project will be graded on a scale from 0 to 100.

- Abstract: 10%. Include a very short description of what you're doing, your main findings, and your contribution to the literature or the usefulness of your findings

- Motivation and literature review 20% (the "literature" may end up being just your motivation paper or a case study). You need to summarize it accurately in 1/2-1 page and say why the issue and your paper are important.

- Methodology and data: 20%. Explain in detail how your analysis is different from your motivation study, or what's new in your project.

- Main results: 20%. Focusing on one regression is okay. Your results need to be technically correct, and interpreted correctly. Your graphs, tables, and summary statistics need to be presented clearly.

- Conclusion: 10% Wrap things up in a clean way. What did you say and why is it important?
    - If you're a graduate student: when you go on the job market, most people will read the abstract, the introduction, and the conclusion. Make sure that they can get your message across.
    - If you're an undergraduate student: most bosses just want the main idea.

- Organization 20%: is your paper mostly grammatically correct? Are tables and graphs visible? If you're unsure about your writing, you can always ask your classmates to proofread it, or take it to the writing center for free feedback.

Presentation: See the sheet posted on course site

I will use the standard Lehigh grading scale to convert your percentage grade to a letter grade.

94-100 = A
90-93 = A-
87-89 = B+
84-86 = B
80-83 = B-
77-79 = C+
74-76 = C
70-73 = C-
67-69 = D+
64-66 = D
60.63 = D-
<60 = F

Course Schedule

The class notes should be sufficient to do well in the class. The suggested readings can be used to supplement your lecture notes. After each topic I list several potential topics for the final project. The listed ideas are suggestions that are meant to help you out if you get stuck and need some inspiration to come up with a topic. You are not restricted to the listed topics and are more than welcome to explore any ideas you want, as long as they use time-series data and at least one method covered in class.

Some of the due dates after Week 7 may be pushed back by a few days. Depending on what students pick as their final projects, I may add to the lecture notes to ensure that you have all of the tools you need to successfully write your papers. If the due dates are moved, they will always be pushed back, not moved forward, and you will be notified at least a week before the due date.

Week 1:

- Intro to macro data: sources, how to download it, uses, what patterns we're looking for
- Review of basic econometric concepts, illustrations in R
- Introduction to difference equations

Background Readings: Class notes (required), Enders Chapter 1 or Hamilton Chapter 1 (supplemental)

Week 2

- Assignment 0 (ungraded, does not have to be turned in, but you need to review the code before you can move on to assignment 1)
- Introduction to difference equations continued
- Persistence, ARMA models, heteroskedastic ARMA models and applications to financial markets
- **Assignments related to this topic**: Assignment 1 (Introduction to Eviews, R and Macro data, introduction to spurious regression)

Background Readings: Class notes (required), Enders Chapter 2 (highly recommended) or Hamilton Chapter 3, Jorda (2005) (optional)
Assignments related to this topic: Assignment 2 (Part 1)

Readings related to week 2 that can be used as final projects and possible extensions:

- Linear projection method Jorda (2005):
  - You can apply the methodology to study the link between two macroeconomic series if you suspect that the relationship may vary over time. For example, you could look at fiscal spending or taxes and their effects on consumption (I can show you where to get data), or the link between interest rates and investment, or unemployment benefits and long-term unemployment, or wages and unemployment (New version of the Phillips curve)

- If you are an engineering and math major and are interested in Fourier or Laplace transforms, and how ARMA models are linked to periodicity: Issues with estimation of MA models: Davis, Chen, and Dunsmuir (1996)
  - You can check if the estimation method is suitable to use when our data sample is small, or when one of the parameters is on the boundary. Alternatively, you can think of a series that is very likely to have an MA component, and apply the DCD approach to test a macroeconomic hypothesis. (See the stochastic trends readings below).

Week 3

- Assignment 1 due
- Maximum likelihood estimation, ARMA processes

Background Readings: Class notes. If you have to miss class or want to do a more in-depth analysis, any econometrics or statistics book with a chapter on MLE should be sufficient.

Assignments related to this topic: Assignment 2: estimating ARMA models, learning how to use template code to estimate different models.

Week 4:

- Assigment 2 due: estimating ARMA models for GDP, consumption, and interest rates in Eviews,

comparing MLE to OLS estimates, estimating an exact maximum likelihood ARMA model
- Deterministic trends and spurious regressions
- Stochastic trends and differencing

Readings: Enders Chapter 4 or Hamilton Chapter 11. Background readings for standard pre-tests built in Eviews, Stata, R: Dickey and Fuller (1979,1981), Kwiatkowski, Phillips, Schmidt and Shin (1992), Leybourne and McCabe (1994). For more updated versions: Morley, Panovska, and Sinclair (2017)

Assignments related to this topic: Assignment 3 (spurious regression, unit root and stationarity tests, introduction to sampling distributions and Monte Carlo simulations using R)

Readings related to week 4 that can be used as final projects: There are several different approaches and topics that you can explore here. If you're interested in writing a paper on any of the topics below, come and talk with me and I can give you a detailed reading list

- You can focus on the econometrics and explore empirically relevant cases in which the unit root and stationarity tests do not work (for example, would an oil crisis make the tests wrong and lead us to mistakenly believe that oil crises permanently decrease output?)
- You can test the PPP theory for a particular time period for a particular country
- You can test the RBC theory that technology is the driver of all movements in output
- You can use the results of the tests to come up with dynamic forecasts for any series of interest (see the readings in Week 5)

Week 5:

- Assignment 3 due
- Forecasting and its links to Machine Learning (predictive analytics)

Readings and papers that can be used as final projects: Hamilton Ch 4; Diebold (2013), Granziera and Sekhsposyan (2018)

Week 6

- Assignment 4 due
- Structural breaks: why they’re terrible for forecasting but useful for policy evaluation

Readings and papers that can be used as a final project: Bai (1997), Qu and Perron (2007), Eo and Morley (2015), Wada (2012), Perron and Wada (2009), Perron and Wada (2016)

Week 7

- Assignment 5 due
- Multivariate models: single equation, VARs, Factor models

Readings and papers that you can use as final project: Sims (1996), Blanchard and Perotti (2002), Baumeister and Hamilton (2016), Arias, Rubio-Ramirez and Waggoner (2018). If you are interested in in writing a paper that uses multivariate analysis, come and talk with me and I will give you a detailed reading list depending on what topic you want to write about.

Week 7

- Assignment due after spring break
- Structural VARs: recursive Identification

Readings: Chib and Greenberg, Can use Kim and Kim (2015) as an idea for a final project (overlaps with week 4)

Week 8:

Spring break

The schedule may change slightly weeks 9-11. I will let you know about any schedule changes at least a week ahead.

Week 9 (tentative)

- Assignment 6: VARs and recursive identification
- Structural identification in VARs: nonrecursive identification
- Readings and papers: see below for week 10.

Week 10 (tentative):

- Cointegration

Readings and papers: same as Week 7+ Blanchard and Quah (1989), Uhlig (2005), Mountford and Uhlig (2009), Christiano, Eichenbaum, and Evans (1999), Arias, Rubio-Ramirez and Waggoner (2018), Baumeister and Hamilton (2016), Granciera, Moon, Schorfheide (2017). There are many different projects that could require multivariate analysis.If you are interested in in writing a paper that uses multivariate analysis, come and talk with me and I will give you a detailed reading list.

Week 11:

- Cointegration

Readings and papers: Enders Ch 6, Morley and Singh (2015), Panovska (2017), Sinclair (2009), Johansen (1988,1991,1994)

Week 12:

- Assignment 7 due
- Principal components and clustering analysis (including links to ML models)
- Regression trees

Week 12 onwards sampler of advanced models. No homework assignments after week 13, so you can focus on finishing your paper. We will have several guest lecturers. The guest lecturers and I will present how we use contemporary nonlinear models in our own research and demonstrate how they're used for policy. I will provide code in case you are interested in using them for your own research or work.

- Bootstrapping and sampling distributions
- Bayesian analysis
- Nonlinear univariate models
- Nonlinear multivariate models
- Predictive analytics with logistical regression, more on regression trees

Readings and papers: Enders Ch 7, Nikolsko-Rzhevskyy, Murray and Papell (2015), Nikolsko-Rzhevskyy, Papell and Prodan (2014), Kim and Nelson (1999)

Week 13:

- **Wednesday: Draft 1 due for your referee (bring two copies: one for your referee, one for me)**

Readings and papers: Terasvirta and Yang (2014a,b), Auerbach and Gorodnichenko (2012), Sims and Zha (2006)

Weeks 14-15:

Week 14:

- **Monday: Referee report due (bring two copies: one for the author, one for me)**
- Presentations, additional survey papers and methodology, guest presenters on advanced time series methods

Week 15:

- Presentations, additional survey papers and methodology, guest presenters on advanced time series methods

Finals week: Final draft and reply to referees due

University Policies

Academic integrity: The work you do in this course must be your own. This means that you must be aware when you are building on someone else's ideas—including the ideas of your classmates, your professor, and the authors you read—and explicitly acknowledge that you are doing so. Discussing the assignments with your classmates is acceptable and encouraged, but any assignments that are turned in must be your own. Feel free to build on, react to, criticize, and analyze the ideas of others but, when you do, make it known whose ideas you are working with. If you ever have questions about drawing the line between others' work and your own, ask me and I will give you clear guidance or you may visit Lehigh's pages

- On plagiarism https://libraryguides.lehigh.edu/plagiarism
- And on citation styles https://libraryguides.lehigh.edu/citation/howtoread

If you are unsure whether your use of somebody else's work could be interpreted as plagiarism, check in with me **before** you turn in your assignment. Ignorance about what constitutes plagiarism is not considered an excuse. If plagiarism or falsification of data is suspected, you will receive an automatic Incomplete F (NF) and will be referred to the University Disciplinary Committee, who will hear your case and determine possible disciplinary action.

Accommodations for Students with Disabilities

Lehigh University is committed to maintaining an equitable and inclusive community and welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact Disability Support Services (DSS), provide documentation, and participate in an interactive review process. If the documentation supports a request for reasonable accommodations, DSS will provide students with a Letter of Accommodations. Students who are approved for accommodations at Lehigh should share this letter and discuss their accommodations and learning needs with instructors as early in the semester as possible. For more information or to request services, please contact Disability Support Services in person in Williams Hall, Suite 301, via phone at 610-758-4152, via email at indss@lehigh.edu, or online at https://studentaffairs.lehigh.edu/disabilities.

Lehigh's Principles of Our Equitable Community: Lehigh University endorses The Principles of Our Equitable Community [http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf]. We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.