

1 Economics 853 and 953: Applied Time Series

Dunning 213 Monday/Wednesday 2:30-3:50

- **Instructor:**

- Allan W. Gregory: MC A522
- E-mail: awg@econ.queensu.ca
- We make extensive use of *onQ* to download notes, programs and other pertinent material. If you have not used *onQ* before, you need to be enrolled in the class to access it.
- Web Page: <http://www.econ.queensu.ca/faculty/gregory/econ853/> (not relevant)
- Office Hours: Monday/Wednesday 4-5pm or by appointment (Elvira Posthumus, Dunning 209)

- **Teaching Assistant (tentative subject to approval):** Raphaelle Gauvin-Coulombe <gauvinr@econ.queensu.ca> Mackintosh Corry Hall A425 (Office Hours: TBA)

- We are both here to assist you along the way, please come by –we get lonely.

2 Background

The goal of this course is to cover the main branches of time series with the aim of application. The theory is terse and meant to be just an introduction to the topic. Serious time series people will want to look far more deeply into the area than the cursory discussions offered here. Our emphasis will be on application; that is, taking the concepts developed in the lectures and employing them in an extended time series project. My lecture notes will be available in a pdf format (on onQ). Where possible, I give the original source of the material, together with some additional references. With a little work, you can usually reference the more recent cutting edge stuff.

The course is about 8 weeks of lectures. I will do about 4 weeks of classes on **stationary univariate time series** (Chapters 1-6 in my notes). After reading week, I will begin topics for 4 weeks. Students may wish to attend all or just concentrate on the areas they find interesting and are working on for their projects.

3 MA Essays

I have always felt that this course should lead naturally into MA essays. That is, students working in second term would encounter ideas and supervisors for MA

essays. Since most of our essays tend to have some empirical time series, the feeling was that a good deal of work could be accomplished in this course on student's essays. Unfortunately, this has not been the case. Instead students do the "work" as set out in the course with no connection to essays. So I am going to once again encourage students to contact potential supervisors and try to develop an idea. At this stage it can be fairly exploratory (that is what this course will do).

4 Grading

The good news is again that there is no exam. The project is worth 100% of the course mark and it will be submitted in 2 stages through-out the term. There will be two projects that should be **no longer than 15 typed double spaced pages (including figures and tables)**. Each project is viewed as a three-week assignment, and the **deadline is taken as given**. No exceptions.

5 Computing

We will use Stata Version 14 in class making use of public access of Queens Wifi. You can download in class files from the class onQ account (all the programs, notes etc.) that you need. Stata works equally well on PCs and Macs but there are some peculiarities in Mac's that you will have to figure out. I use a PC machine and so you cannot always simply follow what I do.

- There are two ways to use Stata
 1. In Dunning 350 and use our machines (PCs). Usually not convenient.
 2. Purchase it yourself (either 6 month, annual, or longer). Some students only need the small version (cleverly named Small Stata) with a limitation of 99 variables, 1200 observations and no 64 bit for \$38 U.S. In the past however, many students have found this too small and I would advise you might want the larger version Stata/IC (\$75) with more variables (2047) and unlimited number of observations (limited by size of your computer memory). For those without credit cards, we might be able to work something out, please send me an email and let me know if that is of interest to you. When you order, you will need a copy of your student ID card (details are here <https://www.stata.com/order/new/edu/gradplans/student-pricing/>)
- Stata instructions "For delivery via electronic download, you will receive an email with download instructions once your order has been submitted. To complete installation, you will need your Activation Key, which will be separately emailed to you once your order is processed. For downloads, order by 3:00 p.m. Central Time, and receive your Activation Key the same day."
- Dunning 350 has a laser printer but you are to supply the paper for your work.

- Finally, keep in mind that any file left in a public site is in jeopardy of being erased without notice. **Therefore do not leave your stuff in our machines.**
- **Also, I believe in sharing computer programs, data sources, tips and general information so you should communicate with one another and not reinvent the wheel.**

6 Downloading Notes from onQ

- All my notes are in a pdf form so that you should be sure to have the latest version available.
- All programs can be downloaded by clicking on the program and saving it to a directory on your computer. I suggest you name a directory for everything you do in my course. Perhaps have a separate one for log files and computer programs and data.
- The directory (folders) have been a challenge for Mac users and I suggest you familiarize yourself quickly with how to retrieve and store data
- **Data has to be in the same directory as programs unless you specify a path**
- There are 2 kinds of programs that I give you:
 1. do files with extension *prog.do* that can be executed directly (provided data can be accessed). There are many of them
 2. ado files with extension *prog.ado* these are programs that are "called" typically by do programs. I have written some of these ado files that you can run to in your own programs. They have more detailed generic commands that you need not be concerned about.
 3. Sometimes I use ado programs that you may not have and these can be downloaded by the command: *search filename* and follow instructions

7 Stages for Project

Before discussing the 2 stages, it is worthwhile discussing a few concerns. A common question:

- *Exactly what is required for the project?*
 - Unfortunately, there is no simple outline to mimic, since each student's project is different, requiring different analysis. Creativity is rewarded, so blindly following my examples does not necessarily lead to first-class grades.
 - The project is to be written up formally .
 - Paper will have: an Introduction, Data, Results, and Concluding Remarks sections.
 - I want you to learn how to do formal academic writing. Indeed, applied econometrics or working with data is as much about writing up your results as it is creating software, graphs and calculating things. The exercises will help you with this.

8 853 and 953 Requirements

We have divided the Econ 853 and Econ 953 with the aim of having different standards for evaluation of MA and Ph.D. students. See departmental rules regarding the credit system for 953.

1. Project 1 (40%)
2. Project 2 (from list) (60%)

8.1 Final Hand-in Date (usually Monday before the final marks are out)

Project 2 must be in the Monday before the marks meetings. There is a mark meeting this week and I need to have your grades in then. No exceptions. If you are not back that week, e-mail me what you have. I intend to hand-in a grade for you.

8.2 Projects in Teams

You are to work in teams of 2 people and the team will hand-in one paper for all stages. In this case, you and your partner receive the same grade. Choose your partners wisely!

9 Project 1: Time Series Empirical Writing and Univariate Analysis (due March 3)

This project is in two parts with equal marks (20% each):

1. Time series academic paper review
2. Univariate short-run time series analysis (with data coming from the paper review ideally)

Although I will not mark it I want to see a rough draft of Part 1 (critique of by February 4. For the final draft, you should try to integrate what you have done into a single paper that includes Part 1 and 2. The entire project should be less than 25 pages in all.

9.1 Part 1: Summarizing and Critiquing an Empirical Paper: Be the referee!

This part needs to be started immediately. You should see yourself in the role of a referee showing that you understand the paper and can explain the research strengths and weaknesses.

- Select an empirical article in economics, formally write-up a model, collect some data relevant for it (you do NOT need it all), and provide some descriptive statistics that perhaps can get at some of the testable implications of this model.
- When choosing a paper look for one in which the emphasis is on a substantive economic problem rather than one that is just advancing a new technique in econometrics. The latter tend to use ‘soft’ rehashed and tired economic examples.
- Econometric models devout of economic theory are to be avoided
- For this section , **I do not want you to attempt anything more sophisticated than general descriptive statistics.**
- A more detailed time series analysis will follow in Part 2
- One good source for the papers and the data is the **Journal of Applied Econometrics** (data archive: <http://qed.econ.queensu.ca/jae/>). The Web is another since many authors have data on their home page to accompany their paper. For example, you might want to check-out a site maintained by Christian Zimmerman at the Federal Reserve Bank of St. Louis (<http://ideas.repec.org/>). There are a great number of links to working papers and economists.

- Your chosen model will comprise a set of time series observations on a dependent variable (or variables) and some set of explanatory variables. **Do not choose a univariate paper!** You are **not** going to estimate this model (often this requires specialized programs and techniques-most of which we don't have yet).
- A project should include:
 1. A clear statement of the economic problem and or model.
 2. A complete description of the data used.
 3. Is the data sources complete?
 4. Could you have replicated the study?
 5. Why did the author write this paper and what were the major findings.
 6. Is the paper any good (citations, accomplish what it set out to, missing analysis)
 7. Provide graphs of the appropriate data and interpret. For instance, does the simple time series graph suggest anything in respect to the theory.
 8. Provide Summary Statistics. Same question. Does these statistics shed any light on the theory.

The part should be no more than 10 pages and there should be a formal write-up.

9.2 Part 2: Univariate Time-Series Models

The project will then move on to the second part which follows the general aspect of the problem to determine an univariate time series representation for a series (hopefully from the article in Part 1). This is intended as a short-run analysis (ie. with transformations leading to stationary data). In the past, this has been a single time series variable but I want to expand the selection to ensure that the series you choose has some interesting short-run dynamics (we will discuss what that means shortly into the course) . The choices are:

1. A single variable y_t that is stationary, can be made stationary by transformations such as first differencing or detrending
2. The spread of two (or more variables, possibly in logarithms) $\omega_t = y_{1t} - y_{2t}$
3. A cointegrated relationship with two (or more variables) $\omega_t = y_{1t} - \hat{\beta}y_{2t}$

I suspect that the choice of this will involve some discussions with me as your work for Part 1 emerges.

This stage will include:

- Identification: autocorrelation and partial autocorrelation functions
 - Estimation
 - Diagnostic Testing
 - Model Selection Techniques
 - Forecasting.(hopefully in real time)

I will provide further details of this in class later in the term.

10 Project 2 Options (Due: End of April)

Students are to choose one (1)

10.1 Vector Autoregressive Modeling (VAR)

For this part, a system approach to the model is required. While it is possible to do some vector ARMA model, it is more likely that the analysis will be a VAR. For this exercise, I would want included:

1. An identification methodology using a variety of selection and testing procedures.
2. A Granger causation study
3. Innovation accounting (impulse response)
4. Systems versus univariate forecasting comparison
5. VAR structural modeling

10.2 ARCH Models

Conditional heteroskedasticity models have become extremely popular in empirical finance. Such conditional volatility models have been used as proxies for unobservable risk premiums. For Stage 3, students can investigate various *ARCH* models in either a multivariate or univariate setting. I would expect such a stage to motivate the modelling strategy and describe the empirical findings in some detail.

10.3 Nonstationarity, Cointegration and Inference

Recent tests and estimation methods for nonstationary time series are to be analyzed. Topics include tests for unit roots, cointegration, estimation, inference, and testing for regime shifts when the break point is unknown.

In addition I will discuss various new topics in nonstationary econometrics. I will not be covering all of these in formal lectures but each student will pick one (or more) of these topics and write a paper discussing and implementing the tests or estimation method. The scope for this stage is wide and I am expecting some insights into the issues in nonstationary econometrics.

10.4 Spectral Analysis

Using some of the information gained in Project 1 students choosing this stage will conduct some frequency decomposition exercise. This exact topic is open so long as it involves some aspect of spectral methods. Students should consult me before starting on this topic. Please keep in mind that while the notes include detailed information on this, it is quite unlikely that this topic is covered in class.

10.5 Kalman Filtering (Stata can now do this as well as any other state space model)

Although it is unlikely that we will have reached this stage in the lectures, students may choose to do a Kalman filtering exercise on their model. Students opting for this should contact me.

10.6 STATA Program of a new time series test or estimator

This is a stage introduced a few years ago which many students found attractive. By this time, students will have developed considerable programming skills in STATA and should be able to write some general code on a new time series test or estimator. We will post these to a Economics 853/953 *OnQ* page (i have some from 2 years ago that I will post soon). Students doing this stage are graded on the econometric problem, the quality of the program, and the clarity of the documentation. No written work other than the code and a successful application are required.

10.7 Any Other Time Series Topic

During the course, students may discover other topics which interest them and that they wish to pursue. I encourage such independence and you can follow such interests in this stage. However, I would ask you to see me *before* starting on this. This is intended to be a step towards an MA essay!

11 Course Outline

We will essentially develop the topics in the order that they are required for the projects. In addition there will be some special topics such as estimating heteroskedastic-autocorrelation consistent variance-covariance matrices, generalized method of moments and regime shifting that are included.

11.1 Textbook and References

There are many fine time series books available (some of which I list below). Unfortunately the books tend to be all theory with little insight for practical application. For the stationary part of the course, we will draw heavily on Harvey and Fuller. The newer nonstationary time series comes from Hamilton and directly from the literature. In addition, some of the lecture material is drawn from other sources not necessarily identified as time series readings.

- Harvey, A.C. (1994) **Time Series Models**, Philip Allan Publishers Limited. Second Edition
- Fuller W.A. (12nd edition 1996) **Introduction to Statistical Time Series**, Wiley Publishers. (good for the spectral stuff)
- Hamilton, J. D. (1994) **Time Series Analysis**, Princeton Publishers.
- C. Chatfield (1989) **The Analysis of Time Series: An Introduction**, 4th edition, Chapman and Hall.
- C.W. J. Granger and P. Newbold (1986) **Forecasting Economic Time Series**, Academic Press, 2nd edition.
- Box, G.E.P. and Jenkins, G.M. (1976) **Time Series Analysis: Forecasting and Control** Holden-Day Publishers.
- Judge, G.G; Griffiths, W.E.; Hill, R.C.; Lütkepohl, H. and Lee, T. (1985) **The Theory and Practice of Econometrics**, second edition, Wiley and Sons Publishers. This is the advanced Judge et al
- Judge, G.G; Hill, R.C.; Griffiths, W.E.; Lütkepohl, H.; and Lee, T. (1987) **Introduction to the Theory and Practice of Econometrics**, second edition, Wiley and Sons Publisher. (The junior version).
- Hannan E.J. (1960) **Time Series Analysis**, Methuen and Co. This is hard.
- Spanos, A. (1986) **Statistical Foundations of Econometric Modelling**, Cambridge Press.
- Cramer, J.S. (1986) **Econometric Applications of Maximum Likelihood Methods**, Cambridge Press. This is a good review of MLE.

- Jenkins, G.M. and Watts D.G. **Spectral Analysis and its Applications**, Holiday Press.
- Dhrymes, Phoebus (1998) **Time Series, Unit Roots, and Cointegration**, Academic Press.
- Banerjee, A., Dolado, J., Galbraith, J. and D. Hendry (1993) **Co-integration, Error-Correction, and the Econometric Analysis of Non-stationary Data**, Oxford University Press.
- Davidson R. And J. G. MacKinnon (new addition) **Estimation and Inference in Econometrics**, Oxford University Press.

12 Course Content and Time Line

12.1 Univariate Time Series (4- 5 lectures, twice a week)

Chapter 1-Introduction

Chapter 2 - Stationary Processes

Chapter 3 - The Box-Jenkins Time Series Model

Chapter 4 - Estimating Time Series Models

Chapter 5 - Asymptotics, Estimation of Covariance Matrices and Hypothesis Testing

Chapter 6 - Model Building: Model Selection Criteria and Prediction

12.2 Topics (each Tuesday for about an hour or so)

Chapter 7 - Multivariate or Vector Time Series Models

Chapter 8 -ARCH Models

Chapter 9 - Heteroskedastic-Autocorrelation Consistent Covariance Matrix Estimation

Chapter 10 - Unit Roots

Chapter 11 - Cointegration (this section is getting huge)

Chapter 12 -Endogenous Regime Shifting (these notes are not done, Stata 14 just introduced this capability)

Chapter - Spectral Analysis (not covered anymore but notes available free of charge if wanted)

13 Queen's Contacts for Data

1. On the *OnQ* page is a document explaining getting data at Queen's University prepared by Jeff Moon (who is an excellent resource person at Stauffer)
 - (a) <http://library.queensu.ca/research/guide/business/economic-statistical>
2. A good source is from Wharton Research Data Services (WRDS) at <http://wrds.wharton.upenn.edu>
 - (a) Account request info is available here: http://library.queensu.ca/db_access/compustat.htm
 - (b) The WRDS reps at Queen's (contacted directly from WRDS when you register.)

14 Data Sources

1. St Louis Federal Reserve Economic data (fred) <http://research.stlouisfed.org/fred2/> can be directly downloaded into Stata (U.S.)
2. U.S. Bureau of Economic Analysis <http://www.bea.gov/index.htm> (U.S.)
3. Bank of Canada <http://www.bankofcanada.ca/en/rates/index.html> (Canada)
4. Statistics Canada <http://www5.statcan.gc.ca/subject-sujet/result-resultat?pid=3764&id=-3764&lang=eng&type=ARRAY&pageNum=1&more=0>
5. Yahoo Finance <http://finance.yahoo.com> (Good for prices and quotes of a variety of US and World stocks)
6. Health data bases <http://www.ihe.ca/publications/health-db/> (usually very short time series)
7. U.S. Bureau of Labor Statistics <http://www.bls.gov/data/>
8. OECD data <http://titania.sourceoecd.org/vl=10567317/cl=14/nw=1/rpsv/home.htm>
9. inGeneas Database <http://www.ingeneas.com/ingeneas/index.html> (contains Canadian passenger, Canadian immigration, Canadian census, Canadian vital statistic (birth, marriage and death), Canadian land, Canadian military and miscellaneous records from the 18th, 19th and early 20th centuries.-costs money)

15 Exercise: Obtaining A Time Series Variable from U.S. Data Base in Stata

1. Open up Stata by double clicking on it . We want to keep two kinds of logs of our session
 - (a) A full log file that records everything that happens (our commands as well as the execution of those commands)
 - (b) A command log file that records the commands we issue and can be used to construct programs (a series of commands conducted sequentially in a do file)
2. Open log file by going to log bar and following directions
3. Type: search freduse. You will be directed to a screen that lets you instal the program *freduse*.
4. Click install. You now have a program that accesses all the data stored on the St. Louis Federal Reserve . We will use this database a lot in this course so be sure you understand how to get variables. Keep in mind the variable has to be spelt exactly the same way as in the data set. Including capital letters.
5. We will retrieve Real Gross Domestic Product US by typing: *freduse GDPC1*. Note that the capital letters for the name must be used and it has to be the exact same way as it is listed in the menu pages of the Reserve.
6. Look at the Reference Manager in drop down dialog and see that 3 variables have been defined and notice their format
7. The variable *daten* is a Stata time variable (*%td*) , in a daily format. This data is actually quarterly (notice the dates are the first of each quarterly month, i.e. January 1, April 1 and so on
8. Create a quarterly variable by typing: *gen time = q(1947q1) + _n - 1*
9. Define this time variable to be the reference one from which all lags (leads) can be defined by typing: *tset time*
10. Go to reference Manager and format the variable and notice the Stata commands are issued from these drop down menus. we will make extensive use of these over the term. Also they can serve as ways to try various things, see what the results are and if you like them, keep the commands for later use.
11. Explore the Graph Bar to see how you can create a graph of real GDP on time, title it, change features of graph.
12. Explore Summarize in Statistics drop down program

13. Type `cmdlog close`
14. Open log file by going to the logfile bar
15. Find `freduse` in the `c:\temp` file using the Stata do file editor, clean up the errors that you made and try to execute all the commands at once.
16. Save the commands to USB key or a temporary file and E-mail them to yourself
17. Welcome to Stata: once you know the commands it is this easy!