Math 641 Time Series I

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Objectives

This course is designed for first and second year graduate students. The purpose is to learn applied statistical methodologies pertaining time series (i.e., a discrete series of observations related in time). It sounds good but the material to be covered is normally subject of a two semester sequence. The students are normally required to have Ma 540 or a solid working knowledge of probability and statistics. Simple regression, estimation and testing from the applied perspective are crucial notions assumed known for this course. We will use R throughout the course so a running knowledge of it is welcome, but not needed.

Textbook(s):

The textbooks for this class are:

- *Analysis of Financial Time Series*, by Ruey S. Tsay, 2^{nd} edition, Wiley-Interscience, Aug 30 2005, ISBN: 047169074, ISBN-13: 978-0471690740 (primary textbook)

- *Statistical Analysis of Time-Series Data in SPlus*, by René Carmona, Springer, March 4, 2004), ISBN: 0387202862 , ISBN-13: 978-0387202860 (recommended text)
- *Introductory Statistics with R*, by Peter Daalgard, Springer; 2002. Corr. 3d printing edition (January 9, 2004) ISBN-10: 0387954759 ISBN-13: 978-0387954752 (recommended text)

Statistical Software

We will use R throughout this course. Students will be expected to install and have the program running on their computers. To this end please read and understand the documents posted on the website, e.g., Introduction to R. For further reference please consult the accompanying R textbook.

Homework, Exams and Grading:

Proper assignment write-up

To understand the course material and get a good grade it is necessary (though not sufficient) to invest a substantial amount of time working on the assignments. Homework consisting of about 5-8 problems will be assigned in class and posted on the web every other week or so. They will be due on the specified due date at the specified time. *No late homework will be accepted under any circumstances.* I will grade two or three problems (selected by me) from each assignment which will count toward 60% of the homework grade, while casually reviewing the other problems for the remaining 40% of the homework grade.

You are encouraged to discuss homework; however, **all written homework must be written by you. Copying solutions from other students in the class, former students, tutors, or any other source is strictly forbidden**. Copying the solution of one or more problems from another source than your own brain is consider academic dishonesty/misconduct and will be dealt with according to the Stevens honor board policy. Please review the document posted on the website which details what is considered fair collaboration and what is considered academic misconduct.

Your solutions must be those that you fully understand and can produce again (and solve similar problems) without help. The ideal model to follow is first to work independently, then to discuss **issues** with your fellow students, and then to prepare the final write-up.

This is going to be an applied course. Therefore, I would expect any solution to a problem in this class to follow the steps bellow:

1. Outline the steps and identify the mathematical techniques learned that pertain to the respective problem.

2. If the problem needs a method first identify and describe the methodology you will apply.

3. Apply the methodology to the problem or the data under study.

4. Very important! Write a conclusion explaining if the application seems to support the method.

Comments about the first two steps. It is expected that in an applied course students spend most time on the final 3rd stage. However, the first two stages are equally important for a successful demonstration of understanding the course concepts. At the beginning of every course the problems are simple enough that the need for the first two stages seem unnecessary but by the end of the class the problems become complicated enough that this will not seem artificial (indeed it will be most helpful).

It is equally important that you do this for the test problems. During a test students have sometime difficulties carrying out all the mathematical analysis to completely solve the problem. If I can see that you know what steps you should be doing, then I can give you more credit than if you just cant carry out the steps and don't tell me anything. Thus, a clearly written plan of your solution method will help you earn a good test grade.

Comments for the third step. As a professional in a quantitative field you will be expected to carry out and provide answers involving real applications.

However, in this class you must show an understanding of why and what of all of the steps involved . Explain what you are doing as if you are teaching it to someone. People who write journal articles often leave out most of the easy steps and just show the hardest steps. That is fine for journal articles, but it is not appropriate for a classroom situation where you need to be convincing the instructor that you understand the reasons for all the steps you are doing.

Comments for the final step. This is of outmost importance. Oftentimes, an applied research article is judged from the contribution to the science as evident in the conclusion. Therefore, the clarity with which you expose this part is perhaps the most important of the entire problem.

Exam policy

We will have one midterm and a final exam. Both exams will be in-class. You will be allowed to bring a handwritten page containing whatever you think is relevant for the exam. I have not yet decided at this time if you will be asked to do real applied problem that will require the use of a notebook pc. In the later case the exam will be open-books open-notes. The date for the midterm will be agreed on during the semester. The most weight for the final grade will be coming from the final examination.

There will be no individual make up exams. If you miss one of the exams, you may be allowed to take a *comprehensive* make up exam (location and time to be determined) at the end of the semester. To be allowed to take this make up exam you have to bring valid written documentation that explains the reason for the missed exam. The make up exam will replace at most one missing exam grade.

Course outline:

- Introduction to Statistical Methods, Visual descriptors, Numerical Descriptors. Simple and multivariate regression, diagnostic checks.
- Linear time series analysis (AR, MA, ARMA).
- Conditional heteroscedastic models (ARCH, GARCH, EGARCH)
- Nonlinear models and applications (TAR, STAR, MSA)
- Bootstrap, Parametric Bootstrap and simulation methods.

This is the main material. Provided enough time is left we may introduce the following topics (normally subject of the second semester)

- Multivariate time series models.

- Multifactor CAPM and APT.
- Principal Component Analysis and Application to Arbitrage Pricing Theory.

Learning Outcomes

A student graduating this course will be expected to have the following specific knowledge.

1. A running knowledge of R that will help with any statistical (and not only) problem.
2. The ability to approach and analyze any discrete time signal from a time series perspective.
3. The ability to differentiate between various time series models.
4. The ability to perform cross-validation of the model developed.