FORECASTING AND TIME SERIES METHODS
QA 725 W 6:00-8:40 P.M.
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Dr. Martin S. Levy
ROOM: 529 LINDNER
TELEPHONE: 556-7145
levyms@email.uc.edu

OFFICE HOURS: Wednesday 5:00 -6:00 PM, and by appointment.

Office hours provide you with an opportunity for personal discussion with me concerning course related problems such as homework, clarification of classroom discussion, text grading, etc. If the formal hours are unsuitable for you, please make an appointment with me at a mutually agreeable time. I strongly urge you to take advantage of these hours.

GROUP WORK STRUCTURE OF THE COURSE: After the first class, each student will join a work group. A work group will consist of at least two students, but no more than six. This work group will be maintained for the length of the quarter. The work group will cooperate in all work given during the quarter including practice problems, studying, and projects (cases and final projects). All members of a group will share grades on any submitted work. All members are to contribute equitably to the shared workload, carrying a fair weight for the burden. At the end of the quarter, members of each group will be asked to evaluate the contribution of the other work group peers on the basis of a number of criteria taking into consideration such factors as intellectual contribution, attendance at group meetings, mentoring and sharing knowledge, writing up the results, and running relevant SAS codes. The peer score will reflect, in some sense, an average over all of the work assigned as well as an average of the criterion above. Thus, a student in a work group who may have contributed much on one assignment, may not have contributed the majority of the work on another, yet still such work may be considered by other members to be meritorious “on the average”.

TESTS: There are two types of projects in this course. Type I projects are exercises in complimenting the Box-Jenkins methodology to case data in the Pankratz text and there will be three sets of such assignments regularly scheduled for submission throughout the summer quarter. These projects (see below) will count as a midterm exam. No in-class exams are planned for this class. The comprehensive final project/exam will be a take-home given on the 10th week of class and due on the following Wednesday at 3:00PM. The exams are to be handed to me, personally or to the QA Secretary in the QA department office. Do not put the exam in my mailbox. No one is exempt from this exam. If you cannot pick up your exam on time you may do so at a later time provided that you inform me first and that you adhere to the specified deadline. The Type II projects are independent studies undertaken by each work group, involving some research into forecasting and time series methods that are not part of the regular lecture material. The individual group will choose from among different topics so that there will be no redundancy in topic selection. For the most part, these topics are quite modern and thus compliment the material that we will cover in class. A brief paper will be submitted to every student in the class for this project and a presentation made by each of the groups tentatively scheduled for the last day of class as well as the time final exam period scheduled by the university. More detail will be provided later.

HOMEWORK: Assignments of text problems will be given in class. My version of the "solutions" will be distributed or placed on the Internet as well. You are urged to collaborate in a responsible manner when attempting the textbook practice problems, i.e. carrying your own weight in any cooperative arrangement. These will not be collected but are intended for practice in mastering the concepts.

GRADING: TYPE I CASE PROJECTS = 50%
FINAL EXAM/PROJECT = 30%
TYPE II PROJECT AND PRESENTATION = 10%
The remaining 10% will be based upon any incidental assignments that are collected and other "intangible" sources that may reflect "attitude" such as participation in class discussion.

MISCELLANEOUS: The “Incomplete” grade will be given only for fully documented medical conditions or other catastrophes *as judged by me*. You may drop the course without penalty up to the Friday of the eighth week of class. No special exams or assignments will be given a quarter's end for grade improvement. Students are responsible for all material, assignments and announcements made in class whether or not they attended the class. All exams/projects must be strictly peer group efforts, when so designated. No collaboration is permitted on any assignments either, *if so designated*. In this class, however, assignments such as the case projects will be designated for group activity. Collaboration only within a group is permitted on such group assignments, including any take-home exams. When required, all work must be shown. No WORK=NO CREDIT. Computer printouts with no explanation will be regarded as “NO WORK”. All computer outputs must be carefully annotated with their purpose and meaning. Inclusion of outputs that are not relevant to the task at hand will result in deduction from credit. Partial credit will be determined solely by me. Of course you may discuss the basis of your grade with me but this discussion must take place in private and not in open class. Keep all graded exams and assignments. The final exam will remain in my possession for two quarters. I regard a student's attitude and interest to be a very important component in evaluation and I reserve the right to raise a grade based upon my impression. You are strongly urged to suggest any improvements in the teaching or classroom procedure. In case a notice of class cancellation is posted, you must remain in class for a period of ten minutes to confirm the validity of that notice. Every student must obtain a ***Blackboard*** account by going to http://blackboard.uc.edu/ on the INTENET. We will use ***Blackboard*** to communicate.

I shall lecture from my own notes, which are synthesized from a number of sources. You will have an opportunity to obtain a copy of these notes, which also will provide you with a transcript of the overhead projector transparencies that I use in class. These will be made available to you at no additional charge. These will be posted in .pdf format on my Blackboard pages. You can download and read these notes and other materials posted in .pdf format using the freeware Adobe Reader. If you do not already have this software, search for it on the web and download a free copy. The topics and sometimes the notation in my notes may differ at times from those in the texts. Nevertheless, you are responsible for the material in both. You must read the Pankratz textbook and try to stay current by selecting the portions of the text that correspond to the week's topic. Because the analyses require the use of a computer program, we will learn how to use some of the forecasting and time series modeling capabilities of SAS, particularly PROC ARIMA. For this reason, the book *SAS for Forecasting Time Series* is essential.

TEXTS: <u>FORECASTING WITH UNIVARIATE BOX AND JENKINS MODELS</u>, Pankratz. This is the main text. Perhaps you can search for a copy on the Blackboard site in .pdf foremat. Reading this book thoroughly is mandatory. Practice problems will be assigned from this book and the cases projects are also here. It is very easy to read as the level is quite modest. Nevertheless, the material is very useful. We will finish this book at about the 7th or 8th week.

<u>SAS SYSTEMS FOR FORECASTING TIME SERIES,</u> 2nd Ed., Brocklebank and Dickey. This is an update of the older edition, and it is quite improved. While I will make no assignments from this text, you obtain a copy for each group and read the material corresponding to each class. If you personally do not buy this book then I very strongly recommend that at least one member of your work group should have a copy. I sincerely believe it is a worthwhile book to own.

<u>APPLIED ECONOMETRIC TIME SERIES</u>, 2nd Ed., WALTER ENDERS. This applied book is written at a level that would appeal to quantitative oriented students. It has shallower depth of coverage of the basic material we will cover in class but has excellent coverage of the more modern elements of time series modeling. You may want this book to help with your type II projects since the topic spectrum I will assign intersects broadly with this book's coverage. Therefore, I will designate it as an optional text but one that I can enthusiastically endorse. I will make no problem assignments from it. The text came highly recommended to me by several forecasting experts whom I respect..

REFERENCE TEXTS: <u>TIME SERIES ANALYSIS: FORECASTING AND CONTROL</u>
BOX AND JENKINS.

<u>SAS/ETS USER'S GUIDE VERSION 9 in SAS Version 9</u>.

<u>FORECASTING EXAMPLES FOR BUSINESS AND ECONOMICS USING SAS SYSTEMS</u> This excellent text has worked examples using SAS and I will occasionally take example from it. If you do not have access to a copy of this book, you may want to borrow a copy from the library. I may have an extra copy as well.

Additional Documentation and Other Resources:
We will be analyzing time series data using a computer. Therefore you may wish to use SAS. There are several PC's around Lindner (in various labs) with these same SAS procedures available using SAS for Windows. Computer labs all around campus in, e.g., Engineering, Education, etc. also have SAS installed. Using these machines carries the disadvantage of requiring your presence on campus but the computing environment is superior to using the mainframe, which I never do, and don't even know how to access. I suggest that you make the latter choice for using SAS. I will provide you with a few 'recipes' for implementing the analyses, but for the most part, you will be able to refer to the SAS manual mentioned below for guidance. Note that you do not have to buy any SAS manuals. All of them are available on ***SAS ONLINE Version 9.1.3*** that you may access at the URL http://support.sas.com/onlinedoc/913/docMainpage.jsp . The main tools in this course are found in the ETS documentation. All computer system inquiries may be addressed to the COB computer consultants who should be well equipped in this regard. Another useful resource is the SAS Statistics manual **SAS/STAT** that contains documentation for many statistical procedures. This is accessible from the on line resource mentioned above, but you can find paper copies of some of these SAS manuals in the computer consultants' office in the COB or in other computer facilities around campus. In addition, you will find SAS manuals on SAS language and other procedures at the URL above.

TYPE I FORECASTING DATA ANALYSIS PROJECTS

I will provide you with some time series cases that are excellent examples of real time series data. (These are the cases in Pankratz.) These are calibrated to have varying degrees of complexity. For the data presented in these examples, the author of that text has indicated his analysis together with many helpful graphs. He has included his rationale for tentative model selection based upon the appearance of the sample autocorrelation function and sample partial autocorrelation, the results of the model parameter estimation, the diagnostic checking and the results of the appropriate forecasting methodology applied to the final model. It is essential that you read these analyses in order to fully understand and appreciate the art of fitting and forecasting time series. I will also give you this author's outline for proper time series analysis that appears in the last chapter of his book.

As a class project in this course, I will require you to perform similar analyses of these some of the time series cases. Specifically, the class will be divided into work groups as described above. Each student will be expected to use SAS ETS to analyze the data. It is your responsibility to gain the proficiency necessary to enter, edit, submit and retrieve a SAS data set. A PC version of SAS for Windows is available on several computers in the COB PC laboratories, on many PC's in the Langsam Computer Lab, and many PC's in the Annie Laws Computer Lab and in the College of Engineering computer labs. There are probably some other locations for accessing SAS on PC's around campus that I do not know about. Some SAS manuals had been available in the consultants' office on the second floor of the COB, but they have a way of disappearing over time. I will be happy to provide you with introductory guidelines for using SAS on the PC's if you wish.
The members of each peer group should cooperate in all matters pertaining to the project, each carrying an equal share of the work burden. You should attempt to coordinate your activities in some efficient way.

From time to time, in class, I will indicate a number of cases that your committee should consider for analysis. The schedule for these assignments will be determined by the pace of the class lectures. The text by Pankratz supplies you with an outline used by that author for his analyses. Your analyses may follow his outline, but must be your own, original work. In addition, since his computer software is old and is not the sam as SAS, the results frequently differ somewhat. Your analysis should contain a discussion of: 1) the identification of the model to be fit together with your rational based upon the appropriate plots. Excerpts from your computer printouts containing these plots will be necessary; 2) estimation of the model parameters (indicating the results of the computer analysis and indication of the method(s) used); 3) diagnostic checking including any statistics and or plots excerpted from the SAS printouts. Forecasting may be attempted after the first case assignment (possibly taking the author's lead times as your own).

You should cooperate in writing these analyses for submission. Your assignments should be terse yet complete, say a page or two of writing (exclusive of the excerpted portions of the printouts) for each example. Photocopy a version for the completed assignment for each committee member to keep as a record. I expect that many of these analyses will coincide with those of the author of the cases, nevertheless, you should be guided in your attempts by the basic principles discussed in the class. Due dates for the assignments will be indicated in class.

TYPE II FORECASTING RESEARCH PROJECTS

Here is a list of topics in the area of time series modeling and forecasting that we will not cover in class.

1. Modeling volatility with ARCH, GARCH, and other methods
2. Modeling time series with trends
3. Multiequation time series models: Vector Auto Regression (VAR)
4. Cointegration and error correction models
5. Nonlinear time series models
6. State space time series models
7. Bayesian time series and forecasting

Each group will select a topic and assign to its members the task of reading and researching material in that topic. A short paper in the form of lecture notes will be prepared synthesizing the material from all group members. The lecture notes should contain:

1. a description of the methods with all definitions and summary of relevant results
2. a discussion of how the method is to be applied and to what type of data
3. a discussion of the underlying assumptions for proper use of the methods
4. an application of the methods to data (that may be obtained form any text, SAS text or manual, or Internet source) using software that is available to the class. For the most part, this will be SAS with the exception that for Bayesian forecasting I will give you a reference for freely available software associated with the source book I will mention below.

A lecture based on these notes will be presented by the members of each group (you will determine how and if to apportion the time to the various group members). Depending on how many topics are to be covered, which in turn depends on how many groups there will be, I will allocate time slots over the last scheduled class as well as the time assigned by the university for this classes' final exam for the presentations. I anticipate that 30 to 40 minutes will be available for each presentation, but we will know more as the course develops.

Note that the first five topics correspond to chapters in the Enders textbook, but also are covered in the SAS text as well to some extent. That is why I recommend obtaining access to these references. Topic 6 is not contained in Enders' book, but is covered in the SAS text. Finally, the 7th topic is contained in none of the books mention yet. I recommend the text *Applied Bayesian Forecasting and Times Series Analysis,* Pole, West, ad Harrison as the source. There is freeware for carrying out the Bayesian modeling and forecasting available on the web and cited in their text.

I would expect that any one of these papers and presentations could easily be developed and expanded to provide the members of a group topics and material for a MSQA project.

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COURSE GOALS, OUTLINE AND POLICIES

The goals of this course are as follows:

1. To introduce the students to the terminology, use and underlying theory (to a small degree) of statistical time series.

2. To expose the students to the univariate Box-Jenkins methodology for fitting and forecasting time series including;
   - (A) Box-Jenkins models
   - (B) Stationarity and non-Stationarity
   - (C) Identification of stationary models using estimated auto-correlation functions.
   - (D) Estimation and model fitting
   - (E) Diagnosing time series models.
   - (F) Forecasting: Point and interval forecasts
   - (G) Transfer function models
   - (H) Intervention models
   - (I) Modern topic in time series and forecasting (via type II projects)

3. To present cases illustrating the above concepts.

4. To make the students aware of other issues not covered in 2.

Achievement of these goals should enable the student to:

1. Communicate effectively with others concerning the use and interpretation of time series models and forecasts.

2. Better understand reports, research, etc., that make use of time series models and forecasts.

3. Pursue further study in this area.

SCHEDULE

CLASS	TOPIC
1	Introduction: Time series data, and Box-Jenkins models
2	AR, MA, and ARMA characterizations
3	Identification of stationary and non-stationary models
4	Model fitting: Estimation
5	Diagnostic procedures
6	Forecasting
7	Seasonal models
8	Transfer function models
9	Intervention models
10	Special topics in forecasting and time series (type II project presentations)
11	Special topics in forecasting and time series (type II project presentations)….continued.