STAT-GB.2302, STAT-UB.0018: FORECASTING TIME SERIES DATA

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TA Info: He Li (hli@stern.nyu.edu), Sundays, 8 - 9 PM, Mondays, 8 - 9 PM (Zoom).

Course Philosophy: This course will cover practical time series forecasting techniques with particular emphasis on the Box-Jenkins (ARIMA) method, and conditional volatility (ARCH) models. Illustrative examples applying these techniques to actual data (primarily financial and economic time series) will be presented in class, and you will perform a variety of data analyses on the computer. To gain a deeper understanding of how the methods work, we will also spend a considerable amount of class time discussing their mathematical/statistical underpinnings. However, most of your grade will be based on data analysis homework problems and projects.

The level of presentation will be somewhere between MBA and MS. MBA students should have no problem handling the data analysis aspects of the course, but will probably find the theory challenging at times. Ph.D. students should also be able to profit from this course, if they want to learn basic forecasting methodology presented at what (for them) should be a rather comfortable mathematical level.

This is a statistics course, and therefore we will not attempt to delve deeply into economic issues. We are concerned here with the statistical analysis and forecasting of time series. No background in economics is required for this course. On the other hand, statistical analysis of economic data, which you will be doing, does form a part of econometrics, and hopefully will often lead to insights of an economic nature.

Prerequisites: One introductory level statistics course covering random variables, expected value, the normal distribution, conditional probability, hypothesis testing, confidence intervals, p-values, correlation and linear regression. It is particularly important that you have some previous exposure to linear regression, because much of the material presented in this course (including the ARMA and ARCH models) is essentially an outgrowth of linear regression. Furthermore, linear regression itself provides a method of forecasting, through trend-line fitting.

Course Work:

There will be weekly homework assignments (data analysis and theory), which count for 45% of the grade. Some of the problems will be demanding, and I will be happy to help you if you run into difficulties. You are free to work with others on homework problems, but it will be assumed that you understand what you have submitted. For teams working together on an entire homework assignment, the team should submit just one file with evereyone's name on it. There will be two data analysis projects (5 pages maximum), each of which counts for 25% of the grade. In the first, which will be due in the middle of the semester, you will analyze a data set of your choice using ARIMA methods. In the second, due at the end of the semester, you will analyze a data set of your choice using ARCH methods. The TA and I will be happy to discuss your projects with you before you hand them in, but beyond this please keep in mind that the projects are individual work. You need to get your own data set and provide a web link to the data. The other 5% of the course grade is for in-class participation. To receive the full five points for participation you should typically contribute at least one question / comment per class meeting. All assignments (both homework and projects) must be in pdf format, and should be submitted on Brightspace.

All handouts and other course materials are available online. Much of the material in the text will not be covered. On the other hand, some of the material in the handouts is not covered in the text.

Optional Textbooks:

 • C.W.J. Granger, "Forecasting in Business and Economics", 2'nd Ed. (Harcourt Brace).

 • F.X. Diebold, "Elements of Forecasting", 4'th Ed. (Thomson).

• W. Enders, "Applied Econometric Time Series". (Wiley).

• T. Mills, "The Econometric Modelling of Financial Time Series", 2'nd Ed. (Cambridge).

You may wish to buy one or more of the books, for supplementary reading. The first few handouts of the course were taken from Granger, as were some of the homework problems in the first few problem sets. Therefore, you might find Granger helpful, at least for the first few weeks. However, most of my lectures are not designed to coordinate exactly with any of the books. Comparing the Diebold and Enders books, I would say that Diebold has more practical examples, and is more enjoyable to read. Enders is written at a considerably higher level, but does contain many real data examples and perceptive data analyses. Enders (but not Diebold) discusses ARCH models.

Software: For the ARIMA examples presented in class on the computer, I will use Minitab 20. All data sets used in class and in homework problems are available on the course website, in Minitab (.mwx) and .xlsx format. The file ReadMe describes the data sets.

For the ARIMA calculations, I recommend that you use Minitab. Minitab 20 is available for your use on apps@stern. A time-limited version of Minitab 20 can be rented from http://www.onthehub.com. This will run on Windows operating systems. There is a simplified version of Minitab, called Minitab Express. Unfortunately, Minitab Express does *not* perform the calculations we need for the course. So, please do not use Minitab Express for this course.

For the ARCH calculations, I recommend that you use R, which can be downloaded for free. For more information, see the course handouts on using R.

If you prefer, you may use any other software you want, provided that it performs the necessary calculations. Any problems arising from this decision, however, are the responsibility of the student. Professor Patrick Perry has materials on using RMD and Rstudio to do the computing for this course, at http://www.ptrckprry.com/course/forecasting. If you use this material, make sure you work with the

updated data files on my course website.

Syllabus:

These are the handouts I have prepared. I may make some small changes during the course of the semester.

I may decide to skip some handouts. In parentheses are the recommended readings from Enders (E)

Diebold (D) and Granger (G) to go roughly with some of the handouts.

Introduction

Chapter 1: Basic Concepts of Forecasting. (D, Chapts 1,3). (G, 1-21).

Linear Prediction of a Random Variable. (D, Chapt 2).

Chapter 2: Trend-Line Fitting and Forecasting. (D, Chapt 5). (G, 23-46).

Chapter 3: Forecasting from Time Series Models

Part I: White Noise and Moving Average Models. (E, 63-66). (D, 117-123, 138-145, 172-175). (G, 47-56).

Part II: Autoregressive Models. (E, 68-72, 76-77, 166-170). (D, 145-152, 177-178). (G, 57-62).

Part III: Mixed Autoregressive - Moving Average Models. (E, 67-68). (D, 152-153, 178-179). (G, 63-65).

Part IV: The Box-Jenkins Approach to Model Building. (E, 78-87). (D, Chapt 7). (G, 65-75).

Part V: More on Model Identification; Examples. (E, 88-99). (D, 28, 82-86 discusses *AIC* and *SIC*). (G, 75-82).

The Corrected *AIC* (AIC_C)

Analysis of Google Series, The Constant Term, Problems with t-ratios

Integrated Moving Averages

Forecast Intervals. (E, 99-101). (D, 41, 175-176, 179-180). (G, 105-108).

Nonlinear Models

Chaos and Nonlinear Time Series

Best Linear Forecasts VS. Best Possible Forecasts

Some Drawbacks of Black-Scholes

ARCH Models and Conditional Volatility (E, 135-158). (D, Chapt 14).

Estimation and Automatic Selection of ARCH Models (E, 162-165).

Long Memory in Volatility

The Durbin-Watson Test. (D, 28-29). (G, 130).

Analysis of Dow and Deflated Dow Series

Differencing and UnitRoot Tests (E, 176-188, 211-261). (D, Chapt 13).

ARCH-M Models (E, 158-162).

Chapter 4, Part I: Cycles and the Seasonal Component. (E, 111-118). (G, 93-100).

Modeling the Federal Reserve Board Production Index

Chapter 4, Part II: Low Cost Forecasting Methods. (This includes Exponentially Weighted Moving Averages, and the Holt-Winters Method). (G, 100-104).