**Course Outline – Spring 2017**
STAT-GB.2302, STAT-UB.0018: Forecasting Time Series Data

## Meeting Time & Place

Lectures: Tuesday, 6:00 PM–9:00 PM
First Lecture: February 7
Class Room: KMC 5-90

## Course Staff

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| Instructor: | Prof. Patrick Perry |
| E-mail: | pperry@stern.nyu.edu |
| Office: | KMC 8-63 |
| Office Hours: | Thursday, 1:30 PM–3:00 PM (or by appointment) |

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| Teaching Fellow: | Sen Tian |
| E-mail: | stian@stern.nyu.edu |
| Office: | KMC 3-60 |
| Office Hours: | Monday and Tuesday, 4:30 PM–5:30 PM |

## Course Website

Handouts, assignments, and data sets will be posted to

`http://ptrckprry.com/course/forecasting/`

Grades will be posted to the NYU Classes website for the course.

## 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. PhD 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 trendline fitting.

## Course Work

There will be weekly homework assignments (data analysis and theory), which count for 50% 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 assignment, you should each submit separate copies of the assignment with your name at the top, followed by the other members of the your team. The grader will assume that all of these papers are identical.

There will be two data analysis projects (five 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 near 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.

You will receive a copy of all handouts used in the lectures. 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

- Granger, C. W. J. (1986). *Forecasting in Business and Economics (2nd ed.)*. New York, NY: Harcourt Brace Jovanovich.
- Diebold, F. X. (2006). *Elements of Forecasting (4th ed.)*. Cincinnati, OH: South-Western.
- Enders, W. (2014). *Applied Econometric Time Series (4th ed.)*. Hoboken, NJ: Wiley.
- Mills, T. (1999). *The Econometric Modelling of Financial Time Series (2nd ed.)*. Cambridge, England: Cambridge University Press.

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

We will use the R software environment for data analysis. R is open source, and can be downloaded for free. There will be a course handout describing how to download and install R.

If you are strongly inclined, you may (after consulting with me) 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.

## Syllabus

We will be using handouts prepared by Prof. Clifford Hurvich, with some small edits. I may make some small changes during the course of the semester. I may decide to skip some handouts. The recommended readings from Enders (E) Diebold (D) and Granger (G) 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*.