Sociology 504: Advanced data analysis for the social sciences

Brandon Stewart, Elisha Cohen and Han Zhang[*]

Class: MW 9:00AM-10:30AM (Wallace Hall 165)
Precept: Th 9:00AM-11:00AM (Location TBD).

Brandon Stewart
bms4@princeton.edu, scholar.princeton.edu/bstewart
Phone: 609-258-5094
Office Hours: When the door is open (Wallace Hall 149)

Elisha Cohen, Preceptor
eacohen1@princeton.edu
Office hours: TBD

Han Zhang, Preceptor
hz2@princeton.edu
Office hours: TBD

1 The Basics

1.1 Overview

This course is the second of the two-semester sequence for Ph.D. students in Sociology. In this sequence, students will learn the statistical and computational principles necessary to perform modern, flexible, and creative analysis of quantitative social data. This course sequence will transform you from consumers of quantitative research to producers of it.

By the end of the semester, you will be able to:

- Conduct, interpret, and communicate results from analysis using generalized linear models.
- Conduct additional study of more advanced topics in quantitative methods
- Build a solid, reproducible research pipeline to go from raw data to final paper.

In terms of statistical content Soc 504 will cover maximum likelihood estimation, generalized linear models and assorted topics helpful for data analysis.

Upon finishing the course sequence, students should be able to read an original scholarly article describing a new statistical technique, implement it in computer code, estimate the model with

[*] Last Edited: April 24, 2016

relevant data, understand and interpret the results, and explain the results to someone unfamiliar with statistics.

The capstone project for the course sequence is a replication project in which students will replicate and extend a piece of scholarly work in the contemporary literature.

As this is a course sequence, it is natural to assume that the structure of the learning process will be the same. However this isn't always the case and the key differences from Soc500 are clearly denoted throughout as "New to Soc504."

1.2 Class and Precept

Formal instruction for the course is split into two pieces: class and precept/lab. The course meets two times a week and will cover the core statistical material. The precept meets once per week and will focus on practical computational skills. Both are an essential part of the learning process.

> **New to Soc504:**
> Class and precept will take on a slightly different role in Soc504. Reading before class will be a more important part of the learning process (although don't worry, we will help you learn how to read statistics effectively). Precepts will also be somewhat more lecture driven and you will take on a bit more responsibility in teaching yourself the `R` code.

1.3 Prerequisites

The most important prerequisite is a willingness to work hard on possibly unfamiliar material. Statistical methods is like a language and it will take time and dedication to master its vocabulary, its grammar, and its idioms. However like studying languages, statistics yields to daily practice and consistent effort.

All students will have needed some previous study in linear regression, preferably Soc 500. However, other classes which cover the matrix approach to multiple regression are also acceptable. Come talk to the instructor if you are unclear whether you have sufficient prerequisites.

2 Materials

2.1 Computational Tools

The best way, and often the only way, to learn new statistical procedures is by doing. We will therefore continue to make extensive use of R as well as a number of companion packages. `R` is probably the most widely used statistical software. We recommend using R with RStudio. A basic foundation in using R is assumed.

2.2 Books

Required Note that the first title will be purchased through an online system described below.

- King, Gary. 1989. *Unifying Political Methodology: The Likelihood Theory of Statistical Inference.* Cambridge University Press.[1]
- Gelman, Andrew and Hill, Jennifer. 2007. Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge University Press.

Required But Free

- Matloff, Norman. 2011. *The Art of R Programming: A Tour of Statistical Software.* No Starch Press. (Available free through the library).
- Blitzstein and Hwang. 2014. *Introduction to Probability*
- A variety of papers, book components will be assigned as well, available on the web.

Suggested It is often helpful to see the same material in alternative ways. Thus here are some other texts you might consult.

- Angrist, Joshua D. and Jörn-Steffen Pischke. 2008. *Mostly Harmless Econometrics: An Empiricist's Companion.* Princeton University Press.
- Morgan, Stephen L, and Christopher Winship. 2014. Counterfactuals and Causal Inference: Second Edition. Cambridge University Press. (available online for free through the library).
- Wickham, Hadley. *Advanced R* (available free online)

3 Assignments

There are three main types of assignments, each of which is described below.

1. **Preparing for class and precept:** For many classes and some precepts there will be some reading that you must do before class. I expect you to come 100% prepared. I will not assign an unreasonable amount of reading and thus I won't spend valuable class time summarizing readings that you should have done before class.
2. **Weekly problem sets:** Learning data analysis takes practice. The problem sets are described below.
3. **Replication Project:** A co-authored paper. See below.

3.1 Readings

There are readings for each topic and they mostly cover the theory of the method along with some applications. Obviously, read the required readings and any others that pique your curiosity.

[1] Why a political science book? The title here is somewhat unfortunate and a product of its time. The book is quite general to the social sciences.

New to Soc504:
Reading will take on a more central role in Soc504 and preparing before class is essential. Reading statistics can be challenging at first. If you don't understand something, that's perfectly fine; we'll figure it out together and make sure no one is left behind.
To this end we will be using a new tool called *Perusall* for the King book *Unifying Political Methodology.* Perusall is a new ebook platform with collaborative annotation that allows you to post and answer questions directly in the text itself. This gives us the opportunity to answer questions outside of class in the text itself. So asking good questions not only helps you, it helps your classmates. If you know the answer to a question that another student posted, please make a contribution to the class and try to answer it!

3.2 Problem Sets

Methods are tools and it isnt very instructive to read a lot about hammers or watch someone else wield a hammer. You need to get your hands on a hammer or two. Thus, in this course, you will have homework on a weekly basis for the first part of the course. The assignments will be a mix of analytic problems, computer simulations, and data analysis.

Assignments should be completed in R Markdown which allows you to show both your answers and the code you used to arrive at them. Don't worry if you don't know R Markdown, we will show you how it works. Your wonderful preceptors will provide you with more detailed instructions before the first assignment is due.

Each week's homework will be made available on Blackboard starting Wednesday at noon and is due Thursday the following week (8 days later) at the start of precept. Solutions will also be available directly after precept through Blackboard. The homeworks will then be graded on a 5-point scale and returned to you within two weeks. No late homework will be accepted except in the case of a documented emergency.

The problem sets including looking at the solutions key is an extremely important part of the learning process, so please keep up with the work!

You can have **one** no questions asked extension of one week on a problem set of your choosing. If you don't take an extension, we will drop your lowest grade (of any partially completed problem set). If all your problem sets are completed and with top-level grades (such that dropping the lowest wouldn't help you), we will add a comparable grade bonus to your final exam. When submitting the work on which you claim the extension please include a note indicating the original date and that you are claiming your one extension; you do not need to explain why you are taking the extension.

Code Conventions: Throughout the course, students will receive feedback on their code from the professor, the preceptor, and other students. Therefore, consistent code conventions are critical. All code written for this class should follow the Hadley Wickham's R Style Guide. Good coding style is an important way to increase the readability of your code (even by a future you!). We will explain how to automatically check your code style using RStudio and a package called lintr.

Collaboration Policy: We encourage students to work together on the assignments, but you should write your own solutions (this includes code). That is, no copy-and-paste from other people's code. You would not copy-and-paste from someone else's paper, and you should treat code the same way. However, we strongly suggest that you make a solo effort at all the problems before consulting others.

New to Soc504:
Each problem set will have one problem which is "no collaboration" (NC). Like the Soc500 final you can use any resources with the exception of other human beings to help with these problems. The preceptors will however be willing to offer some assistance with the problem in office hours. It is okay if the NC problems aren't perfect- we understand that limiting collaboration will make this harder for some students, but it will also increase learning.

3.3 Help

We know that statistics can be challenging and help is available when you need it. We have made every effort to give you the tools you need to succeed in this course. Ultimately though it is your responsibility to put in the effort and seek out that help.

First, the readings provide ample sources of information and the suggested reading list contains many versions of the same material but presented from a different angle. Precept material and lecture slides will all be posted on Blackboard and can then be referenced.

For questions about the material and problem sets we will be using Piazza. You will not be required to post, but the system is designed to get you help quickly and efficiently from classmates, the preceptors, and the professor. Unless the question is of a personal nature or completely specific to you, you should not e-mail teaching staff; instead, you should post your questions on Piazza. The course staff will be monitoring the page, but we encourage you to help your classmates as well. I will post the link to the course page here at the start of class

The preceptors will be holding 2 hours of office hours each week. Brandon will explain his office hour policy in class.

New to Soc504:
You will also be able to post questions directly in the reading through Perusall. Seeking help on the NC problems will be described further in class.

3.4 Grading

Grades in the course will be assigned according to the following breakdown: 10% participation (including online), 30% problem sets, 60% final paper.

3.5 Replication Project

The main assignment is a research paper that applies some advanced method to, or develops one for, a substantive problem in your field of study. The goal of the paper is to write a publishable article. I know, it sounds hard, but that's only because you haven't learned some of the material we go over in class. There will be no final exam.

You must choose a co-author and a paper to replicate by Wednesday, March 2, at 5pm, by which point you should submit via email a PDF copy of the paper along with a brief paragraph explaining your choice. On Wednesday, March 23, you must turn in a draft of the paper with little text but with figures and tables, and a proposed table of contents for your paper, in a relatively polished form. You should also post to the course dropbox all the data and information necessary to replicate the results of your analysis and reproduce your tables and figures. On that day, we will give your paper and data to another student we choose, and give you another student's paper. Your task for the following week is to replicate the other student's analysis and write a memo to this student (with a copy to us), pointing out ways to make the paper and the analysis better. You will be evaluated based on how helpful, not how destructive, you are.

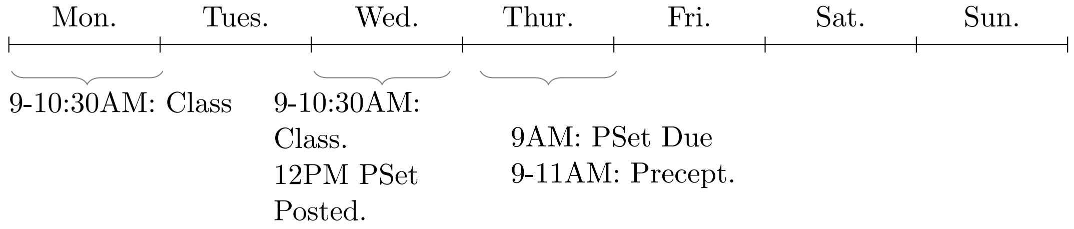
On May 6 we will have a poster session in which students can share their results and get feedback from others in the class and the broader community.

The final version of the paper is due Friday, May 13 at 5PM. We will discuss the format for the paper more in depth in class but it will be loosely based on the submission format for *The Proceedings of the National Academy of Science* which is given here. This is a fairly rigid and short format that places a heavy focus on a concise presentation of findings.

The final assignment of the class is that you will provide a short memo reviewing a paper from one of your classmate's. The memo will offer feedback in the style of a review and will help provide some guidance towards publication. This will be due Monday, May 16 at 5PM.

3.6 Weekly Schedule

The timeline below gives the outline of the weekly schedule. We will fill in as more times are set.



9-10:30AM: Class

9-10:30AM: Class. 12PM PSet Posted.

9AM: PSet Due 9-11AM: Precept.

4 Course Outline

The following is a preliminary schedule of course topics. We may adjust the schedule due to comprehension, time, and interest. Readings will be announced in class.

- Week 1: Introduction and Theories of Inference
- Week 2: Maximum Likelihood Inference
- Week 3: Qois and Binary Outcome Models
- Week 4: Generalized Linear Models, Probit/Logit
- Week 5: Categorical Analysis / Poisson Regression
- Week 6: Event Counts and Duration Modeling
- Week 7: Model Dependence and Matching Basics

- Week 8: Causal Inference and Matching Part II
- Week 9: Mixture Models and Expectation Maximization
- Week 10: Missing Data
- Week 11: Regularization and Hierarchical Models
- Week 12: Multilevel and Hierarchical Modeling

5 Inspirations

The development of this course has been influenced by a number of people particularly: Gary King, Matt Salganik, Teppei Yamamoto. Thanks to all of these excellent teachers for sharing their slides and syllabi with me.