17.804: Quantitative Research Methods III

Fall 2021

Instructor: In Song Kim
TA: Adam Kaplan

Department of Political Science
Massachusetts Institute of Technology

1 Contact Information

	In Song	Adam
Office:	E53–407	**TBD**
Phone:	617–253–3138	**TBD**
Email:	insong@mit.edu	akapl@mit.edu

2 Logistics

- Lectures: Mondays and Wednesdays **9:30–11:00am**, E53-438
- Recitations: **TBD**, E53-438
- In Song's office hours: Make an appointment
- Adam's office hours: **TBD**

Please note:

- For the **first class** we will be meeting in the Millikan Room (E53-482).
- We will have **no class** on October 11 (Indigenous Peoples' Day) or November 24 (the Wednesday before Thanksgiving).
- **Everyone** must comply with all of MIT's Fall 2021 COVID-19 regulations, which includes wearing face coverings during the class session.

3 Course Description

This class is the third course in the quantitative research methods sequence at the MIT political science department. Building on the first two courses of the sequence (17.800 and 17.802), this class covers advanced statistical tools for empirical analysis in modern political science. Our focus in this course will be on techniques for *model-based inference*, including various regression models for cross-sectional data (e.g., binary outcome models, discrete choice models, event count models, etc.),

as well as grouped data (e.g., mixed effects models and hierarchical models). This complements the methods for *design-based inference* primarily covered in the previous course of the sequence. This course also covers basics of the fundamental statistical principles underlying these models (e.g., maximum likelihood theory, theory of generalized linear models, Bayesian statistics) as well as a variety of estimation techniques (e.g., numerical optimization, bootstrap, Markov chain Monte Carlo). The ultimate goal of this course is to provide students with adequate methodological skills for conducting cutting-edge empirical research in their own fields of substantive interest.

4 Prerequisites

There are three prerequisites for this course:

1. Mathematics: Intermediate college-level calculus and linear algebra.
2. Probability and statistics covered in 17.800 and 17.802, including linear regression and basic causal inference.
3. Statistical computing: familiarity with at least one statistical software. We will use R and STAN in this course (more on this below).

For 1 and 3, we expect the level of background knowledge and skills equivalent to what is covered in the department's Math Camp II; see

https://canvas.mit.edu/courses/11657

5 Course Requirements

The final grades are based on the following items:

- **Problem sets** (40%): Weekly problem sets will be given throughout the semester. Problem sets will contain analytical, computational, and data analysis questions. Each problem set will count equally toward the calculation of the final grade. The following instructions will apply to all problem sets unless otherwise noted.
  - Problem sets should be submitted electronically on Canvas *by the beginning of class (9:30 am) the day it is due.* Neither late submission nor printed problem sets will be accepted unless you ask for special permission from the instructor in advance of the deadline. (Permission may be granted or not granted, with or without penalty, depending on the specific circumstances.)
  - Working in groups is encouraged, but each student must submit their own write-up of the solutions. In particular, you must not simply copy and paste someone else's answers or computer code. *Violation of this policy will be considered an academic integrity issue and processed accordingly to MIT's rules and procedures for such violations.* We also ask you to write down the names of the other students with whom you solved the problems together on the first sheet of your solutions.
  - For analytical questions, you should include your intermediate steps, as well as comments on those steps when appropriate. We will allow handwritten answers to some analytical problems *as long as the write-ups are readable.* If you choose to hand-write your answer to these questions, we ask that you upload a scanned copy of your work and include

it in your problem set submission. For data analysis questions, include annotated code as part of your answers. All results should be presented so that they can be easily understood.

- **Quizzes** (15%): Three in-class, closed-book quizzes will take place on October 4, November 1, and November 22 during the regular class time.
- **Final project** (35%): The final project will be a short research paper which typically applies a method learned in this course to an empirical problem of your substantive interest. The paper should be approximately 10 pages in length and contain a concise statement of the research question, description of the data, empirical strategy, results, and conclusions. Literature reviews, theoretical background and motivations should be either omitted or kept to a minimum. You should also submit a copy of your analysis code. Co-authoring is generally encouraged, though political science Ph.D. students should be mindful that a co-authored seminar paper cannot be used as the basis of their second-year paper. Replication papers are also accepted as long as they methodologically go beyond the original analysis in some significant manner.

  Students are expected to adhere to the following deadlines:

  - September to early October: **Start** thinking about possible topics, exploring data sources, and running simple analyses on acquired data sets. Run your ideas by the TA and instructor during their office hours and after classes/recitations to obtain their reactions.
  - October 20: Turn in a **brief description of your proposed project**. By this date, you need to have found your co-author, acquired the data you plan to use, and completed a descriptive analysis of the data (e.g. simple summary statistics, cross-tabs, and plots). Meet with the instructor to discuss your proposal during his office hours. You may be asked to revise and resubmit the proposal two weeks after the meeting.
  - December 6 and 8: Students will give **presentations in front of the class** during the regular class time. Presentations should last about 10 minutes (determined based on the class size, but time limits will be strictly enforced) and take the form of presentations at major academic conferences, such as the APSA and MPSA annual meetings. Students should prepare electronic slides to accompany their presentation. Performance on this presentation will be counted toward the class participation grade (see below). Students will be expected to make final revisions to their papers based on the feedback.
  - December 8: **Final paper due.** Please turn in one copy of your paper by the end of the day on Canvas, and email electronic copies to the instructor and TA.

- **Participation and presentation** (10%): Students are strongly encouraged to ask questions and actively participate in discussions during lectures and recitation sessions.

In addition, there will be recommended readings and lecture notes. Students are strongly encouraged to complete readings prior to the lectures in order to get the most out of them.

6 Course Website

You can find the Canvas website for this course at:

https://canvas.mit.edu/courses/10382

We will distribute course materials, including readings, lecture slides and problem sets, on this website.

7 Questions about Course Materials

In this course, we will utilize an online discussion board called *Piazza*. This is a question-and-answer platform that is easy to use and designed to get you answers to questions quickly. We encourage you to use the Piazza Q & A board when asking questions about lectures, problem sets, and other course materials outside of recitation sessions and office hours. You can access the Piazza course page either directly from the below address or the link posted on the Canvas course website:

https://piazza.com/mit/fall2021/17804

Using Piazza will allow students to see and learn from other students' questions. Both the TA and the instructor will regularly check the board and answer questions posted, although everyone else is also encouraged to contribute to the discussion. A student's respectful and constructive participation on the forum will count toward his/her class participation grade. *Do not email your questions directly to the instructors or TAs* (unless they are of a personal nature) — we will not answer them!

8 Recitation Sessions

Weekly recitation sessions will be held in E53-438 between **TBD**. Sessions will cover a review of the theoretical material and also provide help with computing issues. The teaching assistant will run the sessions and can give more details. Attendance is strongly encouraged.

9 Notes on Computing

In this course we use R, an open-source statistical computing environment that is very widely used in statistics and political science. (If you are already well versed in another statistical software, you are free to use it, but you will be on your own.) Each problem set will contain computing and/or data analysis exercises which can be solved with R but often require going beyond canned functions and writing your own program.

In addition to the materials from the department's math camps (see above), there are many resources for statistics and data science using R that are targeted at both introductory and advanced levels. Examples:

- Fox, John and Sanford Weisberg. 2010. *An R Companion to Applied Regression*. Sage Publications.
- Venables, W. N. and B. D. Ripley. 2002. *Modern Applied Statistics with S*, 4th ed. Springer.
- Wickham, Hadley and Garrett Grolemund. 2017. *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data*. O'Reilly Media.
- For specific questions about R, searching the CRAN website or Stack Overflow with appropriate keywords will often yield satisfactory results.
- There are a lot of other useful online resources, especially about newer-generation packages oriented for data science applications. Check out materials on RStudio's website (documentations, cheatsheets, videos, webinars, etc.).

- As a last resort, you can post your question to the R help e-mail list, but be sure to read the posting guidelines before doing so, and follow exactly what they say. The list is run by a very busy group of people (you will frequently get answers from R Core team members) and they can be nasty if you are not respectful of the norms.

For Bayesian statistical modeling, we also use STAN, a cross-platform, open-source software for Bayesian statistical inference. STAN uses syntax similar to R and comes with an easy-to-use interface with R. Currently the STAN project website is the best place to learn the language.

10 Books

- Recommended books: We will read chapters from these books throughout the course. We strongly recommend that you at least purchase (1) either one of the first two books, (2) Gelman and Hill, and (3) Gelman et al. These books can be purchased at online bookstores (e.g. Amazon) and they will be on reserve in the library.
  - Wooldridge, Jeffrey. 2010. *Econometric Analysis of Cross Section and Panel Data*, 2nd ed. MIT Press. (A standard reference for applied econometricians for most topics covered in the first part of the course.)
  - Cameron, Colin and Pravin Trivedi. 2005. *Microeconometrics: Methods and Applications.* Cambridge University Press. (Slightly less standard, but covers most of the topics throughout the course.)
  - Gelman, Andrew and Jennifer Hill. 2006. *Data Analysis Using Regression and Multilevel/Hierarchical Models.* Cambridge University Press. (A standard, non-technical textbook for Bayesian hierarchical models.)
  - Gelman, Andrew, John B. Carlin, Hal S. Stern, David B. Dunson, Aki Vehtari and Donald B. Rubin. 2014. *Bayesian Data Analysis*, 3rd ed. Chapman and Hall/CRC. (A standard textbook on applied Bayesian statistics.)
- Optional books: These books are standard references for specific topics covered in this course. We will assign a chapter or two from them. Those chapters will be on electronic reserve. Nice books to have for advanced students, but no need to purchase only for this course.
  - McCullagh, P. and J. A. Nelder. 1989. *Generalized Linear Models*, 2nd ed. Chapman and Hall/CRC. (Generalized linear models)
  - Efron, Bradley and Robert J. Tibshirani. 1994. *An Introduction to the Bootstrap.* Chapman and Hall/CRC. (Bootstrap)
  - Kalbfleisch, John D. and Ross L. Prentice. 2002. *The Statistical Analysis of Failure Time Data*, 2nd ed. Wiley. (Survival analysis)

11 Tentative Course Outline

11.1 Generalized Linear Models and Extensions

Binary Outcome Models

1. Binary Logit and Probit Models

   Recommended:

- Wooldridge Ch.15 or Cameron & Trivedi Ch.14

2. Theory of Maximum Likelihood Estimation

   Recommended:

   - Wooldridge Ch.13 or Cameron & Trivedi Ch.5, 7.2–7.4
   - Buse, A. 1982. "The Likelihood Ratio, Wald, and Lagrange Multiplier Tests: An Expository Note." *The American Statistician*, 36(3), 153–157.

3. Numerical Optimization

   Recommended:

   - Wooldridge Ch.12.7 or Cameron & Trivedi Ch.10

4. Bootstrap and Monte Carlo Approximation

   Recommended:

   - Efron & Tibshirani, Ch.6
   - King, Gary, Mike Tomz and Jason Wittenberg, 2000, "Making the Most out of Statistical Analysis: Improving the Interpretation and Presentation." *American Journal of Political Science*, 44(2), pp.341–355.

   Optional:

   - Wooldridge Ch.12.8.2 or Cameron & Trivedi Ch.11

Discrete Choice Models

1. Multinomial Logit and Probit Models

2. Ordered Logit and Probit Models

   Recommended:

   - Wooldridge Ch.16 or Cameron & Trivedi Ch.15

   Optional:

   - Alvarez, R. Michael and Jonathan Nagler, 1995, "Economics, Issues and the Perot Candidacy: Voter Choice in the 1992 Presidential Election." *American Journal of Political Science*, 39(3), 714–744.

Event Count Models

1. Theory of Generalized Linear Models

   Recommended:

   - McCullagh & Nelder, Ch.2
   - Gelman & Hill, Ch.6

   Optional:

   - McCullagh & Nelder, Ch.9.1, 9.2

2. Event Count Models

   Recommended:

   - Wooldridge Ch.18 or Cameron & Trivedi Ch.20
   - Wand, Jonathan N., Kenneth W. Shotts, Jasjeet S. Sekhon, Walter R. Mebane, Jr., Michael C. Herron and Henry E. Brady. 2001. "The Butterfly Did It: The Aberrant Vote for Buchanan in Palm Beach County, Florida." *American Political Science Review*, 95(4), 793–810.

Models for Panel and Multilevel Data

1. Fixed and Random Effects Models

   Recommended:

   - Wooldridge, Ch.10 or Cameron & Trivedi, Ch.21
   - Green, Donald P., Soo Yeon H. Kim and David Yoon, 2001, "Dirty Pool," *International Organization*, 55(2), 441–468.

2. Mixed Effects Models

   Recommended:

   - Gelman & Hill, Ch.11
   - Zorn, Christopher J.W., 2001, "Generalized Estimating Equation Models for Correlated Data: A Review with Applications," *American Journal of Political Science*, 45(2), 470–490.

   Optional:

   - Cameron & Trivedi, Ch.22.8, 24.6

11.2 Bayesian Statistical Modeling

Introduction to Bayesian Statistics

1. Basic Concepts of Bayesian Statistics

   Recommended:

   - Gelman et al., Ch.1, 2, 3, 4 and 5.

2. Markov Chain Monte Carlo

   Recommended:

   - Gelman et al., Ch.10, 11 and 12.

   Optional:

   - Jackman, Simon, 2000, "Estimation and Inference via Bayesian Simulation: An Introduction to Markov Chain Monte Carlo," *American Journal of Political Science*, 44(2), 375–404.
   - Casella, George and Edward I. George, 1992, "Explaining the Gibbs Sampler," *The American Statistician*, 46(3), 167–174.
   - Chib, Siddhartha and Edward Greenberg, 1995, "Understanding the Metropolis-Hastings Algorithm," *The American Statistician*, 49(4), 327–335.

Bayesian Statistical Modeling

1. Hierarchical Linear and Nonlinear Models

   Recommended:

   - Gelman & Hill, Ch.12, 13

   Optional:

   - Gelman & Hill, Ch.14, 15

2. Missing Data

   Recommended:

   - Gelman et al. Ch.18

   Optional:

   - King, Gary, James Honaker, Anne Joseph and Kenneth Scheve. 2001. "Analyzing Incomplete Political Science Data: An Alternative Algorithm for Multiple Imputation". *American Political Science Review*, 95(1): 49–69.

3. Measurement and Item Response Theory

   Recommended:

   - Jackman, Simon. 2009. *Bayesian Analysis for the Social Sciences.* Wiley. Ch.9.

Optional:

- Treier, Shawn and Simon Jackman. 2008. "Democracy as a Latent Variable." *American Journal of Political Science*, 52(1): 201–217.
- Clinton, Joshua, Simon Jackman and Douglas Rivers. 2004. "The Statistical Analysis of Roll Call Data." *American Political Science Review*, 98(2): 355–370.