Conduct of Inquiry IV: Causal Inference
SPA 615

Ryan T. Moore*

19 March 2019 at 11:05

Course Information

School of Public Affairs SPA 615
Conduct of Inquiry IV: Causal Inference
Section 002: Wednesday, 2.30–5.20pm
Kerwin 202

Instructor Information

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Course Description

This course is an introduction to causal inference for the social and biomedical sciences. We will discuss the nature of causal research, how to design research to answer different types of causal questions, how to analyze experimental and observational data, how to implement analysis using the R statistical language, and how to interpret the results of causal analyses. Specific topics will include potential outcomes, experiments, observational matching, sensitivity, instruments, discontinuities,

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synthetic controls, and other special topics as permitted, including mediation, interference, and time-varying treatments.

Learning Objectives

By the end of the course, you should be able to

- Identify causal effects using the potential outcomes framework
- Perform design-based inference for randomized experiments
- Create and analyze variety of randomized designs, including for blocked, conjoint, list, and multiarm bandit experiments
- Identify appropriate designs for causal inference in observational data, implement them, and interpret them; these include matching, instrumental variables, regression discontinuities, and synthetic controls
- Assess the sensitivity of estimates to unmeasured confounders
- Estimate mediation effects and assess their sensitivity

Learning Strategies

Readings

Readings should be completed before the course meeting under which they are listed below.

Computers and Notes in Class

For most class meetings, we will focus our attention on statistical concepts. We will also discuss implementation of statistical methods in R. There will often be time in class to pose questions about code, and we will work on data analysis exercises in R. As such, you may want to bring a laptop to class to try out new code, to update your code files, etc. That said, when it comes to note-taking, the experiments are relatively small, but longhand writing on paper appears to be a superior strategy for taking notes under some conditions. See http://j.mp/2uJAp6z for a summary brief. At least, there is no evidence that note-taking via laptop is beneficial in

> Mueller, Pam A. and Daniel M. Oppenheimer. The Pen is Mightier than the Keyboard: Advantages of Longhand Over Laptop Note Taking. *Psychological Science*, 25(6):1159–1168, 2014.

Requirements and Evaluation

Students are required to do the weekly reading, attend class, complete all assignments, and contribute significantly to course discussions about the material.

The student's final course assessment includes three components: problem sets (weighted 50%), a final exam or paper (40%), and engagement in course conversations through attendance, in-class participation, and Slack participation (10%). Each component will be scored 0-10.

A summary of the course assessments is in Table 1.

Assignment	Weight	Due date
Problem Sets (10)	50%	Weekly
Final exam or paper	40%	May 1
Participation	10%	(throughout)
(Attendance, Slack, quizzes)		

Table 1: Course Assessment Summary

If you cannot submit an assignment on time, arrange to submit it early. We encourage you to use office hours to discuss any specific assignments, difficulties, or questions about the course.

Academic integrity is a core value of institutions of higher learning. It is your responsibility to avoid and report plagiarism, cheating, and dishonesty. Please (re-)read the University policy on academic integrity at http://www.american.edu/academics/integrity/code.cfm, particularly Sections I and II.

Problem Sets

The problem sets should be completed outside of class. You may work with others currently taking the course on the problem sets, but every keystroke of your submission must be your own. You may not copy code or answers from others, but you may develop your code with classmates. You are responsible for understanding every line of code you submit.

Final Exam or Project

If you choose to do a final project, you will select data sets, pose an appropriate causal political, policy, or methodological research question that the data can answer with quantitative methods, analyze the data, and write a paper using this research.

Your project should represent original data analysis, and should address a question of interest to the research community. It should represent quantitative social science at the highest level you can muster. You may work with at most one other student on the final project. Working collaboratively is typical in political science research.

If you choose to take the final exam, it will occur during the scheduled exam time on 1 May 2019.

Software, Statistics, Data, and Literature Support

The primary software for the course is R. See http://j.mp/2swvN0p for help getting started. Support for statistical software is available through CTRL. See http://j.mp/ZrBr2Z for CTRL's workshop schedule.

The Department of Mathematics and Statistics offers statistical consulting services, with extensive hours. For the schedule and contact information, see http://j.mp/1EmVqkY.

The library itself offers support for various software. Our librarian is Olivia Ivey, whom I recommend reaching out to as you formulate a question, search for data, and try to put your question in a larger intellectual or policy context. You can schedule time with her at oliviaivey.youcanbook.me.

Intellectual Property

Course content is the intellectual property of the instructor or student who created it, and may not be recorded or distributed without consent.

Course Evaluation

The course evaluation will take place online towards the end of the semester. Please take time to provide this important feedback.

Replication Policy

Students must retain copies of all `.R` and `.Rmd` files that include their data processing and analysis for problem sets, labs, and the final project. In keeping with standard practice in the discipline, these files should be able to be run by others, and should reproduce all results the student submits.

Further Information for American University Students

For further detailed information on the important issues of academic integrity, emergency preparedness, academic support, discrimination, and use of social media, please see here.

Calendar

16 January

Introduction to causal inference.
The potential outcomes framework. Estimands.
Introduction to computing environments.

- ☐ Required reading: This syllabus.

23 January

Randomized experiments I: Motivation, inference, testing.
Due: PS0 (R/RMarkdown Introduction)
Potential outcomes framework:

- ☐ Paul Holland. "Statistics and Causal Inference". *The Journal of the American Statistical Association*, 81(396):945–960, 1986.
- ☐ Roderick J. Little and Donald B. Rubin. Causal effects in clinical and epidemiological studies via potential outcomes: concepts and analytical approaches. *Annual Review of Public Health*, 21(1):121–145, 2000.

Randomized experiments:

- ☐ Chapters 2 and 3:

  Alan S. Gerber and Donald P. Green. *Field Experiments: Design, Analysis, and Interpretation*. WW Norton, New York, NY, 2012.

30 January

Randomized experiments II: Covariates, blocked designs.
Due: PS1 (potential outcomes)

- ☐ Moore, Ryan T. "Multivariate Continuous Blocking to Improve Political Science Experiments". *Political Analysis*, 20(4):460–479, Autumn 2012.
- ☐ Moore, Ryan T. and Sally A. Moore. "Blocking for Sequential Political Experiments". *Political Analysis*, 21(4):507–523, 2013.

6 February

Survey experiments. Conjoints, item counts, lists.
Due: PS2 (experiments, covariates, blocked designs)

- ☐ Paul M. Sniderman. Some advances in the design of survey experiments. *Annual Review of Political Science*, 21:259–275, May 2018.
- ☐ Jens Hainmueller, Daniel J. Hopkins, and Teppei Yamamoto. Causal inference in conjoint analysis: Understanding multidimensional choices via stated preference experiments. *Political Analysis*, 22(1):1–30, 2014.
- ☐ Yusaku Horiuchi, Daniel M Smith, and Teppei Yamamoto. Measuring voters' multidimensional policy preferences with conjoint analysis: Application to japan's 2014 election. *Political Analysis*, 26(2):190–209, 2018.
- ☐ Graeme Blair and Kosuke Imai. Statistical analysis of list experiments. *Political Analysis*, 20(1):47–77, Winter 2012.
- ☐ Graeme Blair, Kosuke Imai, and Jason Lyall. Comparing and combining list and endorsement experiments: Evidence from afghanistan. *American Journal of Political Science*, 58(4):1043–1063, 2014.

13 February

Multiarm bandits.

- ☐ Molly Offer-Westort, Alexander Coppock, and Donald P Green. Adaptive experimental design: Prospects and applications in political science. *Manuscript.*, 2018. http://j.mp/2FsHlKr.
- ☐ Volodymyr Kuleshov and Doina Precup. Algorithms for multi-armed bandit problems. *CoRR*, abs/1402.6028, 2014.
- ☐ Neha Gupta, Ole-Christoffer Granmo, and Ashok Agrawala. Thompson sampling for dynamic multi-armed bandits. In *2011 10th International Conference on Machine Learning and Applications Workshops*, pages 484–489. IEEE, 2011.

20 February

Observational studies: Designs for causal inference.
Due: PS3 (conjoints, bandits)

- ☐ Donald B. Rubin. The design *versus* the analysis of observational studies for causal effects: Parallels with the design of randomized trials. *Statistics in Medicine*, 26(1):20–36, 2007.
- ☐ Daniel Ho, Kosuke Imai, Gary King, and Elizabeth Stuart. Matching as Nonparametric Preprocessing for Reducing Model Dependence in Parametric Causal Inference. *Political Analysis*, 15:199–236, 2007.
- ☐ Kosuke Imai, Gary King, and Elizabeth A. Stuart. Misunderstandings between experimentalists and observationalists about causal inference. *Journal of the Royal Statistical Society, Series A*, 171(2):481–502, 2008.

27 February

Matching on the propensity score.
Due: PS4 (observational and experimental designs)

- ☐ Paul R. Rosenbaum and Donald B. Rubin. "The Central Role of the Propensity Score in Observational Studies for Causal Effects". *Biometrika*, 70(1):41–55, 1983.
- ☐ Kosuke Imai and Marc Ratkovic. Covariate balancing propensity score. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, 76(1):243–263, 2014.

6 March

Matching on coarsened measures.
Due: PS5 (propensity score matching)

- ☐ Stefano M. Iacus, Gary King, and Giuseppe Porro. Causal inference without balance checking: Coarsened exact matching. *Political Analysis*, 20(1):1–24, Winter 2012.

13 March

No class. Spring Break.

20 March

Sensitivity.
Due: either a) a short memo describing your question, data, and methods for the final project, or b) a short memo confirming that you will take the final exam and describing a core idea covered thus far that you are finding challenging.

- ☐ Kosuke Imai, Luke Keele, and Teppei Yamamoto. Identification, Inference, and Sensitivity Analysis for Causal Mediation Effects. *Statistical Science*, 25(1):51–71, February 2010.

27 March

Encouragement designs, instrumental variables. "Local" treatment effects.
Due: PS6 (sensitivity)

- ☐ Joshua D. Angrist, Guido W. Imbens, and Donald B. Rubin. Identification of causal effects using instrumental variables. *Journal of the American Statistical Association*, 91 (434):444–455, 1996.

3 April

Regression discontinuity designs. Milestones.
Due: PS7 (encouragements and instruments)

- ☐ Devin Caughey and Jasjeet S. Sekhon. Elections and the Regression Discontinuity Design: Lessons from Close U.S. House Races, 1942–2008. *Political Analysis*, 19(4):385–408, 2011.

- ☐ Guido W. Imbens and Thomas Lemieux. Regression discontinuity designs: A guide to practice. *Journal of Econometrics*, 142:615–635, 2008.

10 April

Synthetic control methods. Interrupted time series.
Due: PS8 (regression discontinuity designs)

- ☐ Alberto Abadie and Javier Gardeazabal. The Economic Costs of Conflict: A Case Study of the Basque Country. *The American Economic Review*, 93(1):113–132, 2003.

- ☐ Alberto Abadie, Alexis Diamond, and Jens Hainmueller. Synthetic Control Methods for Comparative Case Studies: Estimating the Effects of California's Tobacco Control Program. *Journal of the American Statistical Association*, 105(490):493–505, June 2010.

- ☐ Alberto Abadie, Alexis Diamond, and Jens Hainmueller. Synth: An r package for synthetic control methods in comparative case studies. *Journal of Statistical Software*, 42(13):1–17, 2011.

17 April

Mediation.

- ☐ Kosuke Imai, Luke Keele, Dustin Tingley, and Teppei Yamamoto. Unpacking the black box of causality: Learning about causal mechanisms from experimental and observational studies. *American Political Science Review*, 105(4):765–789, November 2011.

- ☐ John G. Bullock, Donald P. Green, and Shang E. Ha. Yes, but what's the mechanism? (don't expect an easy answer). *Journal of Personality and Social Psychology*, 98(4):550–558, 2010.

- ☐ Kosuke Imai, Luke Keele, and Teppei Yamamoto. Identification, Inference, and Sensitivity Analysis for Causal Mediation Effects. *Statistical Science*, 25(1):51–71, February 2010.

24 April

Interference. Time-varying treatments and covariates.
Due: PS9 (synthetic controls, mediation)

- ☐ Michael G. Hudgens and M. Elizabeth Halloran. Toward Causal Inference With Interference. *Journal of the American Statistical Association*, 103(482):832–842, June 2008.
- ☐ Paul R. Rosenbaum. Interference Between Units in Randomized Experiments. *Journal of the American Statistical Association*, 102(477):191–200, 2007.
- ☐ Michael E. Sobel. What do randomized studies of housing mobility demonstrate?: Causal inference in the face of interference. *Journal of the American Statistical Association*, 101(476):1398–1407, 2006.
- ☐ Matthew Blackwell. A framework for dynamic causal inference in political science. *American Journal of Political Science*, 57(2):504–520, 2013.

1 May

Final exam or final paper.