PSC405: Causal Inference

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Office Hours: By Appointment
Office: 322 Harkness Hall

Web: Linked Here
Class Hours: M/W 9:40-10:55am
Class Room: Online Only

Teaching via Zoom

This course will be offered in an online-only format to ensure the safety of students, faculty, and staff. All lectures, office hours, and appointments will be held virtually over Zoom (please see links and details below). All assignments will be submitted via Blackboard.

Zoom Link for Lecture: https://rochester.zoom.us/j/93836959938 (Passcode: 146112021)
Zoom Link for Office Hours: https://rochester.zoom.us/j/98061108788 (Passcode: 548074)

Course Description

The central focus of this course is a field growing across the social sciences: causal inference. Specifically, this course is about how and when we can make causal claims from empirical evidence. This is hard thing to do, and the bulk of the difficulty rests in making and justifying assumptions about the world that have to hold in order to allow you to say that something causes something else. While we’ll learn lots of formulas, none of these - nor any computer program, will get you to causal inference without a rigorous interrogation of your assumptions. This course will provide you with the analytic and quantitative framework to assess and implement these assumptions. Perhaps at the most basic level, this course will sharpen your senses toward the issues of causal reasoning in the social sciences. The structure of the class will mix lectures, discussions, and problem sets. After this class you should understand and be able to apply the standard set of causal inference tools in the social sciences. These include: randomized experiments, matching, weighting, fixed effects, differences-in-differences, instrumental variables, regression discontinuity designs, marginal structural models, and sensitivity analyses.
Prerequisites

This is a graduate-level course. Students who take this course should have had some exposure to probability and inference, linear models, and basic R programming.

Qualified undergraduates or students from other departments are welcome to take this course.

Class Structure

This is primarily a lecture-based course, but students are encouraged to participate actively throughout each lecture by asking questions of me and other students, answering questions asked by me or other students, and bringing up any comments or concerns they have about material.

Assignments

Final grades for the course will be based on:

Class Participation (10%): In-class discussion is an important part of this course, and students are expected to contribute regularly to the conversation. Participation can take a variety of forms, including (but not limited to): asking questions of me or other students in the class, answering questions I pose in class, answering questions posed by other students, or offering commentary on course materials. Quality is more important than quantity.

Problem Sets (50%): It’s virtually impossible to learn new methodological tools without using them yourself. Accordingly, students will be responsible for completing a set of (approximately) bi-weekly problem sets. To receive credit for a problem set, each student must submit a well-formatted .pdf writeup of his/her/their own solutions along with an individual R (or .Rmd) script file containing all relevant code.

Final Project (40%): In lieu of a final exam, students in this course will complete a 5-15 page research proposal as individuals. This research proposal will detail plans for an original research project (replications of existing work are not permitted). Students will present their project proposals to the class at the end of the semester. Each research proposal should contain:

1. A brief description of the topic and why it might be an important one to study
2. A description of the research question and hypotheses
3. A description of the data the student has collected or plans to collect in order to address the research question
4. A description of the research design the student plans to use and all of the assumptions the researcher has to make in order to interpret the main quantity of interest as a causal finding
5. A description of the methodology the student will apply in order to obtain results

Literature reviews and other material should either be omitted or included in an appendix.
**Academic Honesty**

I wholeheartedly encourage collaboration. You may work together on the problem sets, but every student must submit individual solutions and code. Copying publicly available solutions wholesale violates the spirit of this course and this program.

**Resources**

If there are accommodations of any sort that would make the class work better for you, please come talk to me about it.

If you think you may need to seek accommodations due to a disability, the Office of Disability Resources can help you figure out your options. Speaking with faculty about disability-related accommodations is strictly confidential; I encourage you to come see me with concerns or requests.

Other resources that may prove helpful during your time at the University of Rochester:

- CARE
- The Writing & Speaking Center
- Tutoring
- University Counseling Center
- David T. Kearns Center
- Office of Minority Student Affairs

**Required Readings**

We will be reading excerpts from the following books in class; these are both available online in full text.

**Books**


2. Hernán, Miguel A. and James M. Robins. 2012. *Causal Inference*. Forthcoming, Cambridge University Press. (Note that this book is still being written and you can find draft PDFs on the linked page above.)
Preliminary Schedule

This schedule is tentative. Please come to class each Monday and Wednesday prepared to discuss the readings listed for that date. Readings marked with a (⋆) are required.

Part I: Introduction to Causal Inference

Monday, 02/01 Introduction to the Course
- Overview
- Course Requirements
- Course Outline

Wednesday, 02/03 Reviewing Statistics Concepts and Notation
- Random Variables
- Measures of Location and Dispersion
- Inference and Properties of Estimators

Monday, 02/08 - Wednesday, 02/10 Potential Outcomes
- Counterfactuals and the Fundamental Problem of Causal Inference
- Graphical Causal Models
- Estimands and Assignment Mechanisms

Reading
- Hernán and Robins, Chapter 1, 6. (⋆)
- Angrist and Pischke: Chapter 1. (⋆)

Monday, 02/15 - Wednesday, 02/17 Randomized Experiments and the “Gold Standard”
- Randomization
- Implementation, Estimation, Diagnostics, Blocking
- Effect Modification

Reading
- Angrist and Pischke: Chapter 2. (⋆)
Monday, 02/22 - Wednesday, 02/24 Randomization Inference
- Fisher’s Approach to Inference
- Sharp Null Hypothesis
- Randomization Distributions
- Permutation Tests

Reading
- Bower, Jake and Panagopoulos, Costas. 2011. Fisher’s Randomization Mode of Inference, Then and Now. (⋆)
- Imbens and Rubin, Chapter 5.

Part II: Selection on Observables

Monday, 03/01  - Selection on Observables
- Identification under Selection on Observables
- Back-Door Criterion
- Subclassification

Reading
- Hernán and Robins, Chapter 7. (⋆)

**Wednesday, 03/03**  *University Study Break Day. No Class.*

**Monday, 03/08 - Wednesday, 03/10**  *Matching*

- Covariate Matching
- Balance Checks
- Properties of Matching Estimators

**Reading**


**Monday, 03/15 - Wednesday, 03/17**  *Propensity Score Methods*

- Propensity Score Estimation
- Matching on the Propensity Score
- Weighting on the Propensity Score
- Reweighting Methods

**Reading**

- Morgan and Winship: Chapter 3.

**Monday, 03/22 - Wednesday, 03/24**  *Regression*
- Non-parametric Regression
- Identification with Regression

**Reading**

- Angrist and Pischke: Chapter 3. (⋆)
- Morgan and Winship: Chapter 5. (⋆)
- Chapter in Winship and Morgan on Matching vs Regression.

**Monday, 03/29 - Wednesday, 03/31 Wrapping Up Selection on Observables**

- Can Non-Experimental Method Recover Causal Effects?

**Reading**


**Part III: Causal Effects under Selection on Time-Invariant Characteristics**

**Monday, 04/05 - Wednesday, 04/07 Panel Data**

- Fixed Effects
- Random Effects
Reading

Theory:
– Angrist and Pischke: Chapter 5.1 (⋆)
– Angrist and Pischke: Chapter 8 (⋆)

Applications:

Monday, 04/12 - Wednesday, 04/14 Differences-in-Differences

- Identification
- Estimation
- Falsification Tests

Reading

Theory:
– Angrist and Pischke: Chapter 5.2-5.4 (⋆)

Applications:
Part IV: Causal Effects under Selection on Time-Variant Characteristics

Monday, 04/19 - Wednesday, 04/21  Instrumental Variables

- Identification
- Estimation
- Falsification Tests

Reading

Theory:
- Angrist and Pischke: Chapter 5.2-5.4 (∗)

Critiques:

Applications:

Monday, 04/26 - Wednesday, 04/28  Regression Discontinuity Designs (RDD)

- Sharp RDD
- Fuzzy RDD
- Falsification Tests

Reading
Theory:
- Angrist and Pischke: Chapter 6 (⋆)

Critiques:

Applications:

Monday, 05/03  Synthetic Controls

- Synthetic Control Models

Reading


Wednesday, 05/05  Final Project Presentations