

Causal Design in Education Research

(SED RS 753)

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Class meetings: Thursday, 5:00-7:45 PM, WED 406

Course overview

This course gives you tools to conduct and understand causal inference in quantitative educational data. We begin by defining causal inference, internal and external validity, and the fundamental challenge of omitted variable bias. We discuss randomized experiments as one solution to this challenge, then introduce a variety of other quasi-experimental methods including instrumental variables, fixed effects, difference-in-differences, and regression discontinuity. By the course's end, you should be able to: evaluate whether other people's causal claims are justified; perform your own causal analysis given educational data; and design your own causal studies using appropriate methods.

Course goals

- Understand the basic statistical assumptions underlying regression analysis and the situations in which these assumptions are appropriate;
- Be able to identify when the basic regression assumptions may be violated and to correct for these violations using appropriate techniques;
- Be able to critically assess empirical studies in education and other professional journals;
- Have proficiency using statistical software such as Stata or R;
- Be able to implement original research using the empirical techniques you have learned.

Common questions

Should you take this course? - Yes, if you care about causal inference in education research.

What prior background is required? – RS 653, or other training in multivariate regression analysis.

What are your obligations as a student in this course? – Do the reading slowly and carefully. Come to class ready for discussion. Invest time in problem sets. Be courteous to your classmates. Use our time wisely.

Texts

There are no required texts for this course, as I'll provide everything you need in the class notes. You may, however, find it helpful to have other references to turn to. I recommend these:

Causal Inference: The Mixtape. Cunningham, Scott. Yale University Press, 2018. [Technical but conversational tone, examples of Stata code, pdf is available for free]

Methods Matter: Improving Causal Inference in Educational and Social Science Research. Murnane, Richard J., and John B. Willett. Oxford University Press, 2010. [Education-specific, fairly dense.]

Mastering Metrics: The Path from Cause to Effect. Angrist, Joshua D., and Jörn-Steffen Pischke. Princeton University Press, 2014. [High-level overview, very readable]

Mostly Harmless Econometrics: An Empiricist's Companion. Angrist, Joshua D., and Jörn-Steffen Pischke. Princeton University Press, 2008. [Deeper, more technical dive, also very readable]

Course grading

Five problem sets, each worth 10% of your grade, will be submitted electronically. Problem sets must be typed. Late problem sets receive no credit. You are encouraged to discuss assignments with other students in the course and form study groups. You must, however, write up your own answers to all questions. Please write the name(s) of any students you have worked with on the first page of the problem set. The lowest problem set grade will be dropped.

A midterm and final exam, each worth 25% of your grade, will be given halfway through and at the end of the course. We'll determine the exact format when the dates draw closer. No make-up exams will be given. Absence from an exam will be excused only for a serious illness or family emergency that is appropriately documented; otherwise a grade of zero will be assigned. An excused absence from an exam will result in greater weight being placed on the other exams in the course.

A final project, worth 10% of your grade, will be due on the last class. The project will ask you to take an existing data set and answer an open-ended question that allows for multiple empirical strategies. I'll ask you to present your approach and findings during the final class. I will likely allow this project to be done in groups of up to 3 students.

Attendance is mandatory. Also, please help facilitate good discussion during class or in office hours. I'll take this into account should your final average be on the margin between two letter grades.

Software

You may use Stata or R to do the empirical exercises. I will teach in Stata but am happy to support you using R.

You can access Stata and other software available in BU computers from anywhere on your own device (see <https://www.bu.edu/tech/services/cccs/desktop/computer-labs/commonfromanywhere>). If off campus, use [Cisco AnyConnect to connect to BU's network](#). You also have access with your ID to campus computers, which have Stata installed. You may be interested in buying Stata for your own computer. Any version of Stata (Stata/BE or Stata/SE) should work fine for this course.

You can download R and R Studio from:

R download: <https://www.r-project.org/>

R Studio download: <https://www.rstudio.com/products/rstudio/download/>

Class	Date	Topic	Assignment Due
1	1/23	<u>Prediction vs. causality</u> - Counterfactuals - Bivariate/multivariate regression - Internal vs. external validity	
2	1/30	<u>Omitted variable bias</u> - OVB formula - Predicting sign of OVB / Over vs. under-estimation - Matching as a strategy	
3	2/6	<u>Randomized experiments</u> - Gold standard for causal inference - Covariate balance - Raw means vs. regression adjustment	PS 1
4	2/13	<u>Complicating randomized experiments</u> - Attrition - Crossovers / no-shows - Spillovers	
5	2/20	<u>Instrumental variables I</u> - In randomized experiments - LATE (compliers) - Intent-to-treat vs. treatment-on-treated	PS 2
6	2/27	<u>Instrumental variables II</u> - IV outside of experiments - Exclusion restriction - Strong vs. weak instruments	
7	3/6	MIDTERM EXAM	PS 3
8	3/20	<u>Regression discontinuity I</u> (+ final exercise introduction) - Sharp RD - Testing for manipulation/heaping - Bandwidth, functional form selection	
9	3/27	<u>Difference-in-differences I</u> - Two groups, two periods - Parallel trends - Synthetic control methods	
10	4/3	<u>Fixed effects</u> - Within vs. between estimators - Family fixed effects	PS 4
11	4/10	<u>Regression discontinuity II</u> - Forum discussion - Fuzzy RD - Multiscore / Multidimensional RD	
12	4/17	<u>Difference-in-differences II</u> - Multiple groups, multiple periods - Fixed effects specifications - Final exercise Q&A	
13	4/24	<u>Guest research presentations</u> TBD	PS 5
14	5/1	<u>Wrap up</u> Presentation of final projects / Course review	
	TBD	FINAL EXAM	

Class 1 - Prediction vs. causality

- Counterfactuals | Bivariate/multivariate regression | Internal vs. external validity

Required reading: [“9 Big Ideas To Bolster the Teaching Profession and Boost Student Learning”](#)
(Barnum, 2023) [Focus on first 2 ideas]

Optional reading: Mostly Harmless Econometrics: Ch. 1
Methods Matter: Ch. 3

Class 2 - Omitted variable bias

- OVB formula | Predicting sign of OVB | Over vs. under-estimation | Matching as a strategy

Required reading: [“State of Knowledge: Innovation Career Pathways”](#) (MA DESE, 2024)

Optional readings: Mostly Harmless Econometrics: Ch. 3.2.2
Mastering Metrics: Ch. 2.3

Class 3 - Randomized experiments

- Gold standard for causal inference | Covariate balance | Raw means vs. regression adjustment

Required reading: [“Experimental Estimates of Education Production Functions”](#) (Krueger, 1999)

Optional readings: Mostly Harmless Econometrics: Ch. 2
Mastering Metrics: Ch. 1
Methods Matter: Ch. 4

[“Why Economists Should Conduct Field Experiments and 14 Tips for Pulling One Off.”](#)
(List, 2011)

Class 4 - Complicating randomized experiments

- Attrition | Crossovers / no-shows | Spillovers

Required reading: [“Worms: Identifying Impacts on Education and Health in the Presence of Treatment Externalities”](#) (Miguel and Kremer, 2004)

Optional readings: Methods Matter: pp. 69-73

[“Using Randomization in Development Economics Research: A Toolkit”](#)
(Duflo, Glennerster, & Kremer, 2006) [Focus on sections 6.2-6.4]

Class 5 - Instrumental variables I

- In randomized experiments | LATE (compliers) | Intent-to-treat vs. treatment-on-treated

Required reading: “[Accountability and Flexibility in Public Schools: Evidence from Boston’s Charters and Pilots](#)” (Abdulkadiroglu, Angrist, Dynarski, Kane, & Pathak, 2011)

Optional readings: Mastering Metrics: Ch. 3.1

Class 6 - Instrumental variables II

- IV outside of experiments | Exclusion restriction | Strong vs. weak instruments

Required reading: “[Do Political Protests Matter? Evidence from the Tea Party Movement](#)”
(Madestam, Shoag, Veuger, & Yanagizawa-Drott, 2013)

["Using Geographic Variation in College Proximity to Estimate the Return to Schooling"](#)
(Card, 1993) [Focus on pp. 1-3]

Optional readings: Causal Inference – The Mixtape: [Ch. 7](#)
Mostly Harmless Econometrics: Ch. 4.1
Mastering Metrics: Ch. 3.3
Methods Matter: Ch. 10

Class 7 – MIDTERM

Class 8 – Regression discontinuity I (+ final exercise introduction)

- Sharp RD | Testing for manipulation/heaping | Bandwidth, functional form selection

Required reading: “[Merit Aid, College Quality, and College Completion](#)” (Cohodes and Goodman, 2014)

Optional readings: Causal Inference – The Mixtape: [Ch. 6](#)

[A Practical Introduction to Regression Discontinuity Designs: Foundations](#)
(Cattaneo, Idrobo, & Titiunik, 2019) [Focus on section 1, 2, 4.1, 5.1, 5.2]

Class 9 - Difference-in-differences I

- Two groups, two periods | Parallel trends | Synthetic control

Required reading: [“The Effect of Human Capital on Earnings: Evidence from a Reform at Colombia’s Top University”](#) (Arteaga, 2018)

Optional readings: Causal Inference – The Mixtape: [Ch. 9](#)
Mostly Harmless Econometrics: Ch. 5.2
Mastering Metrics: Ch. 5.1

Class 10 - Fixed effects

- Within vs. between estimators | Family fixed effects | Student fixed effects

Required reading: [“Early Childhood Intervention and Life-Cycle Skill Development: Evidence from Head Start”](#) (Deming, 2009)

[“The Effects of Special Education on the Academic Performance of Students with Learning Disabilities”](#) (Schwartz, Hopkins, & Stiefel, 2021) [Focus on introduction]

[“Heat and Learning”](#) (Park, Goodman, Hurwitz, & Smith, 2020) [Focus on introduction]

Optional readings: Mostly Harmless Econometrics: Ch. 5.1

Class 11 - Regression discontinuity II

- Fuzzy RD | Multi-score / Multi-dimensional RD

Required reading: [“Can Online Delivery Increase Access to Education?”](#) (Goodman, Melkers, & Pallais, 2019)

[“Take Two! SAT Retaking and College Enrollment Gaps”](#)
(Goodman, Gurantz, & Smith, 2020) [Focus on introduction, Figures 1 and 2]

[“Access to Four-Year Public Colleges and Degree Completion”](#)
(Goodman, Hurwitz, & Smith, 2017) [Focus on introduction, Equation 4]

Optional readings: [A Practical Introduction to Regression Discontinuity Designs: Extensions](#)
(Cattaneo, Idrobo, & Titiunik, 2023) [Focus on sections 3 and 5]

Class 12 - Difference-in-differences II

- Multiple groups, multiple periods | Fixed effects specifications | Final exercise Q&A

Required reading: [“The Labor of Division: Returns to Compulsory High School Math Coursework”](#)
(Goodman, 2019)

Optional readings: [“What’s Trending in Difference-in-Differences? A Synthesis of the Recent Econometrics Literature”](#) (Roth, Sant’Anna, Bilinski, & Poe, 2023)

Class 13 – Guest research presentations

Class 14 - Wrap up

- Presentation of final projects
- Course review