CAUSAL INFERENCE IN QUANTITATIVE EDUCATIONAL AND SOCIAL SCIENCE RESEARCH

Lecture: Mondays and Wednesdays 3-4:20p.m., CERAS 513

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"To a person with a hammer, everything looks like a nail."

Course rationale

Assessing the causal effects of policies and practices is one important aim of educational and social science research. Educational researchers may want to know, for example, what effect a given teaching practice has on student learning, what effect accountability policies have on teaching practices, or what effect early childhood education programs have on school readiness. Social scientists may want to know what the effect of certain neighborhood conditions are on child development or the effect of a behavioral choice on subsequent outcomes. Informed policy and practice decisions, including the allocation of resources, should rely on the best available credible evidence of the causal effects of the policies and practices in question.

Historically, however, much educational and social science research has not been designed in such a way as to allow researchers to make causal inferences about the effects of educational practices and policies. In part, this is because many quantitative studies in education and the social sciences are essentially correlational in nature. That is, they may show that there are statistical associations between various policies and practices and outcomes, but they do not provide strong, convincing evidence of the causal linkages among these variables.

In recent decades, however, the so-called counterfactual or potential outcomes model (also called the "Rubin Causal Model") and related developments have dramatically changed the way that social scientists think about causality. While the most dramatic influence of this model is in economics, it has also begun to influence quantitative work in the fields of sociology, political science, education, and public health. The Rubin Causal Model is a precise logical framework for thinking about causality—and what constitutes evidence of causality—in the social sciences.

Course aims

This course will provide students with hands-on practice using data from experimental and quasi-experimental studies to estimate treatment effects using the Rubin Causal Model. Specifically, the course will provide training in a) the analysis of randomized experiments, including multi-site randomized trials; b) instrumental variables analysis; c) fixed effects analysis; d) regression discontinuity analysis; e) interrupted time-series and difference-in-difference analysis; and g) matching methods and synthetic control.

Prerequisites

The course is designed for graduate students with prior training in applied multivariate regression techniques and the formal logic of experimental designs for causal inference. The prerequisites for enrollment include satisfactory completion of EDUC 255A (or an equivalent) and completion of a course in multivariate regression (e.g. EDUC 400B, ECON 102B, SOC 382, etc.).

Course structure

The course will meet twice per week in 80-minute sessions, and once per week in an optional 80-minute section. Typically, but not always), the Monday class will include a lecture describing a specific method of analysis and the Wednesday class will involve reviewing the previous week's problem set in class.

This is an advanced graduate course, suitable for students in a PhD program. Consequently, the following should go without saying: We expect that students in the course are motivated by a desire or felt need to learn the course material. Thus, we expect students in this course to come to each class having carefully read the readings and prepared with questions. Students who have not done the reading will likely benefit little from the course.

Laptop use

A growing body of evidence suggests that the use of laptops, tablets, and phones in classrooms tends to be detrimental to learning. In general, we discourage their use on lecture days. However, if you want to use a device during class, we ask that you contact us *outside of class* to make this request. For more context on this policy, see this video.

A note for students with disabilities

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk; phone: 723-1066; web site http://studentaffairs.stanford.edu/oae.

Readings

Readings will consist of an assortment of methodological and empirical papers and a set of class notes, provided on Canvas. The following resources may also be useful but are not required:

Angrist, J. D. and Pischke, J. S. (2009). *Mostly Harmless Econometrics*. Princeton University Press.

Angrist, J. D., & Pischke, J. S. *Mastering 'metrics: the path from cause to effect*. Princeton University Press.

Murnane, R. J., & Willett, J. B. (2011). *Methods matter: Improving causal inference in educational and social science research.* Oxford University Press.

Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., & Vermeersch, C. M. (2016). *Impact evaluation in practice*. World Bank Publication.

Software

Students should do all problem sets using STATA version 13, 14, 15, or 16. Students need not purchase Stata statistical software for this course, as it is available in the Education School computer labs, but if you wish to purchase it, a discounted student version of the standard of Stata is available. Details are available at:

https://itservices.stanford.edu/service/softwarelic/stata

Assignments

Six Group Problem Sets — *total of 60% of final grade*

This is a hands-on course in statistical analysis. Thus, most weeks students will complete a problem set based on an analysis of a data set that will be provided. There will be 6 such problem sets. Students will work in groups on all the assignments. Each problem set will be graded out of ten points. Problem sets that show a concerted effort to fully address each aspect of the problem set will receive at least 8 points. The final 2 points are awarded on the basis of thoroughness, clarity, and appropriate use of the methods. All members of a group will receive the same grade. Problem sets are to be uploaded as a PDF before the due date. Each group will submit their written responses (e.g., "group1_ps2.pdf"), their STATA code for each problem set (e.g., "group1_ps2.do"), and their short answer questions (e.g., "group1_ps2.xlsx"). Students will work in groups assigned at the beginning of the quarter.

Two Individual Memos — *total of 30% of final grade*

In addition to the applied group problem sets, there will be two individual response memos. These memos will test your understanding of the various methodologies to make causal inference that we discuss in class. Upload the individual memos in PDF format to the Canvas site by the due date. Please name your individual problem set with your name and the problem set number from the syllabus (e.g., "trejo_sam_memo1.pdf")

Course attendance and discussion participation— *10% of final grade*

Our expectation is that students attend all class sessions and participate in discussion of the empirical papers and problem sets. Please contact us in advance for excused absences.

Final presentation (optional)

Students in this class often wish to receive constructive feedback on the ways in which they plan to apply the methodologies introduced in this course in their own research. In the last week of classes, we have time available for students who want to make brief presentations and receive such feedback. If you plan to take advantage of this option, please inform us of your topic and method via email by February 12th (i.e., a short paragraph). Presentations will occur on March 4th. You should make a PowerPoint presentation with no more than 10 slides. You may choose (or decline) to have this effort graded to replace your lowest problem set grade.

Section (optional)

Section will be held weekly on Thursday. The purpose of section is to review the method discussed in class and learn Stata commands to execute analyses required in the problem set.

A note on academic integrity:

Academic integrity is the pursuit of scholarly activity free from fraud and deception and is an educational objective of this institution. Academic dishonesty includes, but is not limited to,

cheating, plagiarizing, fabricating information, facilitating acts of academic dishonesty by others, and submitting the work of another person or work previously used without informing the instructor. The Honor Code, outlining the general expectations pertaining to Academic Integrity applicable to this course, is published in the Graduate Student Handbook available at: http://honorcode.stanford.edu. Students are expected to conform to the highest standards of academic integrity in this course — meaning, essentially, don't lie; don't cheat; don't pass off someone else's work as your own.

Course Schedule

Week 1

Monday, January 6, 2020

Course overview. Analyzing randomized experiments. Randomization checks. Attrition analysis.

Required Readings:

Kreuger, A. B. (1999). Experimental estimates of education production functions. *Quarterly Journal of Economics*, 114 (2): 497-532.

Supplemental Readings:

Angrist, Joshua D., and Jörn-Steffen Pischke (2010). "The Credibility Revolution in Empirical Economics: How Better Research Design Is Taking the Con out of Econometrics." *Journal of Economic Perspectives*, 24(2): 3-30.

Athey, S., & Imbens, G. W. (2017). "The state of applied econometrics: Causality and policy evaluation." *Journal of Economic Perspectives*, 31(2), 3-32.

Rubin, D. B. (2005). Causal inference using potential outcomes: Design, modeling, decisions. *Journal of the American Statistical Association*, 100(469), 322-331.

Assignment

Problem Set #1 Assigned (Due Sunday, January 12, 2020 by 11:59pm)

Wednesday, January 8, 2020

Analyzing multi-site trials. Estimating the average within-site treatment effect. Fixed-effects models. Meta-analysis. Estimating the variance of treatment effects. Random-coefficient models (HLM). Shrinkage estimator. Hypothesis testing regarding the variance of treatment effects. Moderators of treatment effects. Weighting.

Required Readings:

Weiss, M. J., Bloom, H. S., Verbitsky-Savitz, N., Gupta, H., Vigil, A. E., & Cullinan, D. N. (2017). How much do the effects of education and training programs vary across sites? Evidence from past multisite randomized trials. *Journal of Research on Educational Effectiveness*, 10(4), 843-876.

Supplemental Readings:

Weiss, M. J., Bloom, H. S., & Brock, T. (2014). A conceptual framework for studying the sources of variation in program effects: Sources of variation in program effects. *Journal*

of Policy Analysis and Management, 33(3), 778–808. http://doi.org/10.1002/pam.21760

Bloom, H. S., Raudenbush, S. W., Weiss, M. J., & Porter, K. (2017). Using multisite experiments to study cross-site variation in treatment effects: A hybrid approach with fixed intercepts and a random treatment coefficient. *Journal of Research on Educational Effectiveness*, 10(4), 817-842.

Week 2
Monday, January 13, 2020

Instrumental variables analysis. Two-stage least squares with a binary treatment variable. Two-stage least squares with a continuous treatment variable.

Required Readings:

Kreuger, A. B. (1999). Experimental estimates of education production functions. *Quarterly Journal of Economics*, 114 (2): 497-532. [Re-read the IV analysis section.]

Goodman, J. (2014). Flaking Out: Student Absences and Snow Days as Disruptions of Instructional Time (No. w20221). Cambridge, MA: *National Bureau of Economic Research*. Retrieved from http://www.nber.org/papers/w20221.pdf.

Supplemental Readings:

Abdulkadiroğlu, A., Pathak, P. A., & Walters, C. R. (2018). Free to choose: Can school choice reduce student achievement?. *American Economic Journal: Applied Economics*, 10(1), 175-206.

For a refresher on IV from a textbook, see, for example: Stock, James, H., & Watson, Mark W. (2007). Chapter 12. Instrumental Variables Regression (pp. 421- 451), in *Introduction to Econometrics* (2nd edition).

Assignments
Memo #1 Assigned (Due Tuesday, January 21, 2020 by 11:59pm)
Problem Set #2 Assigned (Due Sunday, January 26, 2020 by 11:59pm)

Wednesday, January 15, 2020

Review Problem Set #1. In-class presentations, discussion.

Week 3
Monday, January 20, 2020
No Class - University Holiday

Wednesday, January 22, 2020

Principal stratification and bounding.

Required Readings:

Miratrix, L., Furey, J., Feller, A., Grindal, T., & Page, L. C. (2018). Bounding, an accessible method for estimating principal causal effects, examined and explained. *Journal of Research on Educational Effectiveness*, 11(1), 133-162.

Page, L. C., Feller, A., Grindal, T., Miratrix, L., & Somers, M. A. (2015). Principal stratification: A tool for understanding variation in program effects across endogenous subgroups. *American Journal of Evaluation*, 36(4), 514-531.

Supplemental Readings:

Lee, D. S. (2009). Training, wages, and sample selection: Estimating sharp bounds on treatment effects. *The Review of Economic Studies*, 76(3), 1071-1102.

Week 4

Monday, January 27, 2020

Basic and multiple fixed effects.

Required Readings:

Dee, T. S. (2005). A teacher like me: Does race, ethnicity, or gender matter?. *American Economic Review*, 95(2), 158-165.

Domingue, B. W., Belsky, D. W., Conley, D., Harris, K. M., & Boardman, J. D. (2015). Polygenic influence on educational attainment: New evidence from the National Longitudinal Study of Adolescent to Adult Health. *AERA Open*, 1(3), 2332858415599972.

Supplemental Readings:

Reardon, S., & Bischoff, K. (2011). Income Inequality and Income Segregation. *American Journal of Sociology, 116*(4), 1092-1153. doi:10.1086/657114

Gershenson, S., Holt, S. B., & Papageorge, N. W. (2016). Who believes in me? The effect of student–teacher demographic match on teacher expectations. *Economics of Education Review*, 52, 209-224.

Assignment

Problem Set #3 Assigned (Due Sunday, February 02, 2020 by 11:59pm)

Wednesday, January 29, 2020

Review Problem Set #2. In-class presentations, discussion.

Week 5

Monday, February 03, 2020

Regression discontinuity analysis. Graphical analysis. Bandwidth selection. Falsification tests. Functional form selection. Fuzzy regression discontinuity analysis.

Required Readings:

Imbens, G. W., & Lemieux, T. (2008). Regression discontinuity designs: A guide to practice. *Journal of Econometrics* 142: 615-635.

Nomi, T. & Allensworth E. (2009). "Double-Dose" Algebra as an Alternative Strategy to Remediation: Effects on Students' Academic Outcomes. *Journal of Research on Educational Effectiveness*, 2 (2): 111-148.

Robinson, J. P. (2011). Evaluating criteria for English learner reclassification: a causal-effects approach using a binding-score regression discontinuity design with instrumental variables. *Educational Evaluation and Policy Analysis*, 33 (3): 267-292.

Supplemental Readings:

Bloom, H. S. (2009). Modern regression discontinuity analysis. *MDRC Working Paper*. [Read parts 2 and 3]

Imbens, G. W., & Kalyanaraman, K. (2009). Optimal bandwidth choice for the regression discontinuity estimator. *Review of Economic Studies* 79 (3): 933-959.

Reardon, S. F., & Robinson, J. P. (2012). Regression discontinuity with multiple rating-score variables. *Journal of Research on Educational Effectiveness* 5 (1): 83-104.

Scott-Clayton, J. (2011). On money and motivation a quasi-experimental analysis of financial incentives for college achievement. *Journal of Human Resources*, *46*(3), 614-646

Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014). Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica*, 82(6), 2295-2326.

Cattaneo, M. D., Titiunik, R., & Vazquez-Bare, G. (2017). Comparing inference approaches for RD designs: A reexamination of the effect of head start on child mortality. *Journal of Policy Analysis and Management*.

Assignment

Problem Set #4 Assigned (Due Sunday, February 09, 2020 by 11:59pm)

Wednesday, February 05, 2020

Review Problem Set #3. In-class presentations, discussion.

Week 6

Monday, February 10, 2020
Difference-in-difference analysis. Interrupted time series and comparative interrupted time series analysis. Graphical analysis. Functional form. Model specification.

Required Readings:

Susan M. Dynarski. 2003. "Does Aid Matter? Measuring the Effects of Student Aid on College Attendance and Completion." *American Economic Review* 279-288.

Supplemental Readings:

Dee, T. S., Jacob, B. A., & Schwartz, N. L. (2013). The effects of NCLB on School Resources and Practices. *Education Evaluation and Policy Analysis*, 35 (2): 252-279.

Bettinger, E. (2015). Need-Based Aid and College Persistence: The Effects of the Ohio College Opportunity Grant. *Educational Evaluation and Policy Analysis*, 37, 102S-119S.

Assignment
Memo #2 Assigned (Due Tuesday, February 18, 2020 by 11:59pm)
Problem Set #5 Assigned (Due Sunday, February 23, 2020 by 11:59pm)

Wednesday, February 12, 2020
Review Problem Set #4. In-class presentations, discussion.

Week 7
Monday, February 17, 2020
No Class - University Holiday

Wednesday, February 19, 2020
Difference-in-difference analysis. Interrupted time series and comparative interrupted time series analysis. Graphical analysis. Functional form. Model specification.

Required Readings:

Reardon, S., Grewal, E., Kalogrides, D., & Greenberg, E. (2012). Brown fades: The end of court-ordered school desegregation and the resegregation of American public schools. *Journal of Policy Analysis and Management*, 31 (4): 876-904.

Rossin-Slater, M., Schnell, M., Schwandt, H., Trejo, S., Uniat, L. (2019). Local Exposure to School Shootings and Youth Antidepressant Use (No. 26563). Cambridge, MA: *National Bureau of Economic Research*.

Supplemental Readings:

Goodman-Bacon, A. (2018). Difference-in-differences with variation in treatment timing (No. w25018). *National Bureau of Economic Research*.

Gibbons, C. E., Serrato, J. C. S., & Urbancic, M. B. (2018). Broken or fixed effects?. *Journal of Econometric Methods*, 8(1).

Assignment
Problem Set #5 Assigned (Due Sunday, February 23, 2020 by 11:59pm)

Week 8
Monday, February 24, 2020
Matching analysis. Propensity score matching. Stratification on the propensity score. Balance checks. Nearest-neighbor matching. 1-1 matching. M-1 matching. Kernel matching. Inverse-probability of treatment weighting. Propensity and prognostic scores.

Required Readings:

Reardon, S. F., Cheadle, J. E., & Robinson, J. P. (2009). The effect of Catholic schooling on math and reading development in kindergarten through fifth grade. *Journal of Research on Educational Effectiveness*, 2: 45–87

Hansen, B. B. (2008). The prognostic analogue of the propensity score. *Biometrika*, 95 (2): 481-488.

Leacy, F. P., & Stuart, E. A. (2014). On the joint use of propensity and prognostic scores in estimation of the average treatment effect on the treated: a simulation study. *Statistics in Medicine*, 33(20), 3488-3508.

Supplemental Readings:

Stuart, E. A. (2010). Matching methods for causal inference: A review and a look forward. *Statistical Sciences* 25 (1): 1-21.

Caliendo, M., & Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys*, 22(1), 31-72.

Guo, S. & Fraser, M. W. (2010). *Propensity Score Analysis: Statistical Methods and Applications*. Sage Press: Thousand Oaks, CA. Chapters 3, 5, 6.

Assignment
Problem Set #6 Assigned (Due Sunday, March 01, 2020 by 11:59pm)

Wednesday, February 26, 2020
Review Problem Set #5. In-class presentations, discussion.

Week 9
Monday, March 02, 2020
Review Problem Set #6. In-class presentations, discussion.

Wednesday, March 04, 2020
Student Presentations

Week 10
Monday, March 09, 2020
Balance weighting and synthetic control (guest lecture by Avi Feller).

Required Readings:

Abadie, A., Diamond, A., & Hainmueller, J. (2010). Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. *Journal of the American statistical Association*, 105(490), 493-505.

Ben-Michael, E., Feller, A., & Rothstein, J. (2018). The augmented synthetic control method. *arXiv preprint* arXiv:1811.04170.

Supplemental Readings:

Abadie, A. (2019). Using synthetic controls: Feasibility, data requirements, and methodological aspects. *Journal of Economic Literature*.

Ben-Michael, E., Feller, A., & Rothstein, J. (2019). Synthetic Controls and Weighted Event Studies with Staggered Adoption. *arXiv preprint* arXiv:1912.03290.

Arkhangelsky, D., Athey, S., Hirshberg, D. A., Imbens, G. W., & Wager, S. (2019). Synthetic difference in differences (No. w25532). *National Bureau of Economic Research*.

Wednesday, March 11, 2020
No Class - SREE Annual Conference

Course Calendar

	Monday	Wednesday
Week 1 01/06/2020	Introduction and Course Overview (Sean & Sam)	Multi-Site Randomized Controlled Trials (Sean) *Problem Set 1 Assigned*
Week 2 01/13/2020	Instrumental Variables (Sean) *Problem Set 1 Due, Memo 1 & Problem Set 2 Assigned*	Review Problem Set 1 (Sam)
Week 3 01/20/2020	No Class — Martin Luther King Jr. Day	Principal Stratification and Bounding (Sean) *Memo 1 Due*
Week 4 01/27/2020	Fixed Effects (Sam) *Problem Set 2 Due, Problem Set 3 Assigned*	Review Problem Set 2 (Sam)
Week 5 02/03/2020	Regression Discontinuity (Sean) *Problem Set 3 Due, Problem Set 4 Assigned*	Review Problem Set 3 (Sean)
Week 6 02/10/2020	Difference in Differences, ITS, and CITS (Sam) *Problem Set 4 Due, Memo 2 & Problem Set 5 Assigned*	Review Problem Set 4 (Sean) *Presentation Topic Due (Optional)*
Week 7 02/17/2020	No Class — Presidents' Day	Difference in Differences, ITS, and CITS (Sam) *Memo 2 Due*
Week 8 02/24/2020	Matching (Sam) *Problem Set 5 Due, Problem Set 6 Assigned*	Review Problem Set 5 (Sean)
Week 9 03/02/2020	Review Problem Set 6 (Sam) *Problem Set 6 Due*	Presentations (Sean & Sam)
Week 10 03/09/2020	Synthetic Control (Avi Feller)	No Class — SREE Annual Conference