

# CAUSAL INFERENCE, 2 DAYS WORKSHOP

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**Overview:** “Correlation is not causation”. You must have heard this warning many times. But, what then is causation, and how can we identify the causal effect of political interventions? This module introduces students to the Neyman-Rubin potential outcomes framework, the independence assumption, and from there, to random treatment assignment and other assignment mechanisms that invoke stronger additional assumptions. The module then covers various analysis strategies that are suitable given the assumed assignment mechanism and data at hand. Those strategies include the regression discontinuity design (RDD), difference-in-differences (DiD), and the synthetic control method (SCM). The module is taught as a combination of lectures and applied computer labs in R.

**Learning Outcomes:** Participants will be familiar with the potential outcomes framework. They will also be able to identify likely treatment assignment mechanisms, the correct estimator, and the assumptions they need to invoke for an estimator to be unbiased. Students will then be equipped with the statistical and computational tools to estimate their quantities of interest. They will also be familiar with common complications in treatment assignment and data generation such as staggered treatment assignment and spatial auto-correlation, and have a toolkit of potential solutions to those challenges at their disposal. The module should equip students to answer their own causal questions across a range of subfields and topics in political science.

**Course Dropbox:** Some readings and all code files are available from the course dropbox.

## Required textbooks

Bauer, Paul C. and Denis Cohen. *Applied Causal Inference with R*. 2020. <https://bookdown.org/paul/applied-causal-analysis/>

Cattaneo, Matias D., Nicolás Idrobo, and Rocío Titiunik. *A practical introduction to regression discontinuity designs: Foundations*. Cambridge University Press, 2019. [Link](#)

de Mesquita, Ethan Bueno, and Anthony Fowler. *Thinking clearly with data: A guide to quantitative reasoning and analysis*. Princeton University Press, 2021.

## Recommended textbooks

Cattaneo, Matias D., Nicolás Idrobo, and Rocío Titiunik. *A practical introduction to regression discontinuity designs: Extensions*. Cambridge University Press, 2024.

Cunningham, Scott. *Causal Inference: The Mixtape*, Yale University Press, 2020. <https://mixtape.scunning.com>

Dunning, Thad. *Natural Experiments in the Social Sciences. A Design-Based Approach*, Cambridge: Cambridge University Press, 2012.

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

Imbens, Guido W. and Donald B. Rubin. *Causal Inference for Statistics, Social and Biomedical Sciences: An Introduction*. Princeton: Princeton University Press, 2015.

**Software:** R Studio will be used throughout this module.

## Workshop Outline

### Day 1

1. Introduction to causal inference: From treatment assignment mechanisms to data
2. Potential Outcomes Framework
3. Regression Discontinuity Design (RDD): Foundations
4. Regression Discontinuity Design (RDD): Application
5. Practical questions

### Day 2

6. Difference-in-Differences Design (DiD): Foundations
7. Difference-in-Differences Design (DiD): Application
8. Synthetic Control Method (SCM): Foundations
9. Synthetic Control Method (SCM): Application
10. Advice on students' research designs

## Introduction

### Reading

*Bauer and Cohen*: Chapter 4

de Mesquita and Fowler, Chapters 3 and 9

Gerber and Green: Chapters 1 and 2

Gelman, Forward Causal Inference

### Content

- What is causal inference?
- Unobserved heterogeneity
- Experiments and quasi-experiments
- Random and quasi-random assignment
- The three core assumptions

## Fundamental problem of causal inference and the ATE

### Reading

*Bauer and Cohen*: Chapter 4

*Cattaneo et al. 2019*: Chapter 2

Gerber and Green: Chapter 2

Holland, Fundamental Problem of Causal Inference

### Content

- Potential outcomes framework
- Fundamental problem of causal inference
- Potential and realised outcomes
- The switching equation
- Difference-in-means estimator of the ATE
- Unbiasedness of the ATE estimator
- ATE, ATT and LATE

## Regression Discontinuity Design (RDD)

### Readings

*Cattaneo et al. 2019*: Chapters 3-5

*Cattaneo et al. 2023*: Chapter 3

Campbell, Donald T. 1969. Reforms as experiments. *American Psychologist* 24(4): 409-429.

*Cunningham*: Chapter 6

*de Mesquita and Fowler*, Chapter 12

*Dunning*, chapters 1 and 3

*Keele, Luke, and Rocio Titiunik*. 2016. "Natural experiments based on geography." *Political Science Research and Methods* 4(1): 65-95.

### Content

- RDD assumptions
- The running and assignment variables
- Polynomial estimation
- Local polynomial estimation

- Different bandwidth estimators
- Robustness checks: Balance tests, density tests, placebo outcomes
- Fuzzy RDD
- Spatial RDD
- [rdrobust package](#)
- [rdpower package](#)

## Difference-in-Differences Design (DiD)

### Readings

*Bauer and Cohen: Chapter 10*

*Callaway, Brantly, and Pedro HC Sant'Anna. Introduction to DiD with Multiple Time Periods*

*Cunningham: Chapter 9*

*de Mesquita and Fowler, Chapter 13*

*Liu, Licheng, Ye Wang, and Yiqing Xu. A practical guide to counterfactual estimators for causal inference with time-series cross-sectional data*

### Content

- *Assumptions (parallel trends, no compound treatment)*
- *TWFE estimator*
- *Example: The Sun and Euroscepticism (Foos and Bischof 2021)*
- *What if parallel trends assumption only holds under specific conditions?*
- *Extension to multiple groups and treatment periods*
- [did package](#)
- [fect package](#)

## Synthetic Control Method (SCM)

### Readings

*Cunningham: Chapter 10*

*Abadie, Alberto, Alexis Diamond, and Jens Hainmueller. 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.*

Abadie, Alberto, Alexis Diamond, and Jens Hainmueller. 2011. "Synth: An R Package for Synthetic Control Methods in Comparative Case Studies." *Journal of Statistical Software* 42(13): 1-17.

Abadie, Alberto, Alexis Diamond, and Jens Hainmueller. 2015. "Comparative politics and the synthetic control method." *American Journal of Political Science* 59(2): 495-510.

## Content

- Basics
- RMSE
- Uncertainty and exact p-value
- [Synth package](#)
- [MSCMT package](#)