Ph.D. in "Life Course Research"
Statistical Methods or Causal Inference
Academic Year 2023-2024

Outline

The course aims to introduce the key concepts and state-of-art methods for causal inference from randomized experiments and observational studies under the potential outcome framework. We will first introduce the basic concepts of the potential outcome framework and the essential role of the treatment assignment mechanism. Then, we will cover different situations corresponding to different assumptions concerning the assignment mechanism. We will discuss the design and analysis of experimental designs and the design and analysis of observational studies with regular assignment mechanisms where the unconfoundedness assumption is assumed to hold. We will introduce irregular assignment mechanisms discussing strategies for deal with experimental studies with noncompliance. Finally, we will cover some advanced topics: principal stratification, mediation analysis, causal inference with survival outcome, regression discontinuity designs, differences-in-differences methods, synthetic control methods and causal inference with time series. We will present example and real case studies from many disciplines, including economics, education, demography, social sciences, epidemiology, and biomedical science. We will use STATA for the practical sessions.

Schedule

Monday - June 3, 2024

2:00 p.m. – 3:30 p.m. (Fabrizia Mealli)

Introduction to the potential outcome approach

1. Potential outcomes and causal effects
2. Sample causal estimands and super-population causal estimand
3. The role of the assignment mechanism in causal inference

4:00 p.m. – 5:30 p.m. (Veronica Ballerini)

Modes of inference

1. Fisher's exact p-value approach
2. Neyman's repeated sampling approach to completely randomized experiments
3. Model-based (Bayesian) approach
4. The role of covariates in randomized experiments

Tuesday - June 4, 2024

10:00 a.m. – 11:30 a.m. (Alessandra Mattei)

Design of observational studies

1. The unconfoundedness assumption: meaning and implications
2. The role of the propensity score in observational studies
3. Designing observational studies: matching, subclassification, weighting, trimming

12:00 p.m. – 13:30 p.m. (Alessandra Mattei)

Analysis of observational studies

1. A classification of the estimation methods: Stratification, weighting estimators, matching estimators, methods based on the outcome models and regression
2. Combined methods (Bias corrected estimators, doubly robust estimators)

3:00 p.m. – 5:15 p.m. (Fiammetta Menchetti)

Lab session: Design and analysis of randomized experiments

Wednesday - June 5, 2024

10:00 a.m. – 11:30 a.m. (Fiammetta Menchetti)

Observational studies: Supplementary analyses

1. Assessing unconfoundedness
2. Sensitivity analysis and bounds

12:00 p.m. – 13:30 p.m. (Veronica Ballerini)

Instrumental Variables analysis

3:00 p.m. – 5:15 p.m. (Giulio Grossi)

Lab session: Design and analysis of observational studies

Thursday - June 6, 2024

10:00 a.m. – 11:30 a.m. (Veronica Ballerini)

Advanced topics

1. Principal stratification
2. Mediation analysis

12:00 p.m. – 13:30 p.m. (Fabrizia Mealli)

1. Causal inference with survival outcomes
2. Introduction to Regression discontinuity designs

3:00 p.m. – 5:15 p.m. (Veronica Ballerini)

Lab session: IV analysis and case study on principal stratification /mediation

Friday - June 7, 2024

10:00 a.m. – 11:30 a.m. (Giulio Grossi)

Difference in difference and synthetic controls: Theory and case studies

12:00 p.m. – 13:30 p.m. (Fiammetta Menchetti)

Causal inference with time series: Theory and case studies

Readings

Lecture notes (with additional references) will be provided in class.

1. Athey, S. and G. W. Imbens (2017). The state of applied econometrics - causality and policy evaluation. Journal of Economic Perspectives, 31(2), 3–32
2. Athey, S. and G. W. Imbens (2017). Chapter 3 - The econometrics of randomized experiments. Handbook of Economic Field Experiments 1, 73-140.
3. Bargagli Stoffi F., Dominici F. and Mealli F. (2021) From controlled to undisciplined data: estimating causal effects in the era of data science using a potential outcome framework. Harvard Data Science Review, 3(3) (https://arxiv.org/abs/2012.06865).
4. Ding, P. and Li, F. (2018). Causal inference: a missing data perspective. Statistical Science. 33(2), 214-237.
5. Imbens G.W., Rubin D.B. (2015). Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction. Cambridge University Press.

6. Li, F, Ding, P., Mealli, F. (2023). Bayesian Causal Inference: A Critical Review. Philosophical Transaction A. 381:20220153

7. Mattei, A. Mealli F., Nodehi A. (2021) Design and Analysis of Experiments. In: Zimmermann K.F. (eds) Handbook of Labor, Human Resources and Population Economics. Springer.

8. Mealli, F., B. Pacini, and D. B. Rubin (2011). Statistical inference for causal effects. In Kenett R. and Salini S. (Eds.) Modern Analysis of Customer Surveys: with Applications Using R, Wiley, 171-192

9. Rubin, D. B. (1974). Estimating causal effects of treatments in randomized and nonrandomized studies. Journal of Educational Psychology 66, 688-701

10. Rubin, D. B. (1976). Inference and missing data. Biometrika 63, 581-592.

11. Rubin, D. B. (1978). Bayesian inference for causal effects: The role of randomization. Annals of Statistics. 6 34-58.