Bayesian Causal Inference

Fabrizia Mealli and Alessandra Mattei

The aim of this course is to introduce the Bayesian approach to causal inference under the potential outcome framework, where causal effects are defined as the comparison of the potential outcomes under different treatment conditions for the same units. The Bayesian paradigm is natural for causal inference, which is inherently a missing data problem under the potential outcome approach. We describe estimands, assumptions, and the general structure of Bayesian inference for the analysis of randomized and observational studies. We will also discuss Bayesian inference for the analysis of causal studies with post-treatment confounded variables (e.g., intercurrent events) including Bayesian Instrumental Variables and Bayesian principal stratification. Real-world case studies will be used to illustrate the methods, including randomized studies with nonnompliance and randomized control trials with treatment switching.

Outline

1. 30 minutes: Introduction to the potential outcomes framework: Basic concepts; finite population and super population causal estimands; the role of the assignment mechanism; modes of inference
2. 60 minutes: Model-based Bayesian approach: Basic structure of Bayesian causal inference for regular assignment mechanisms
   - Basic factorization and versions of causal estimands; posterior inference of causal effects; and model specification
3. 120 minutes: Bayesian causal inference with irregular assignment mechanisms
   - 60 minutes: Bayesian instrumental variables with application to randomized studies suffering from noncompliance
   - 60 minutes: Bayesian principal stratification analysis with application to randomized clinical trials with treatment switching

Learning Objectives

1. Learn the fundamentals of the potential outcomes framework
2. Learn the basic structure of Bayesian causal inference
3. Understand the role of the structural and model assumptions in Bayesian causal inference
4. Understand the notion of identifiability in Bayesian causal inference
5. Implement Bayesian causal inference using R

Target Audience. Students, postdocs, or professional statisticians who are interested in Bayesian approaches to causal studies. The course requires some basic knowledge of the potential outcome appraoch to causal inference and Bayesian inference. Familiarity with the basics of R is useful, but not necessary.

About the instructors

Fabrizia Mealli is Professor of Econometrics at the Department of Economics of the European University Institute (EUI). Her research focuses on causal inference, programme evaluation, estimation techniques, simulation methods, missing data, and Bayesian inference, with applications to the economics, social and biomedical sciences. She has published numerous articles and research papers in various scientific journals. She is an associate editor of "Observational Studies," "The Annals of Applied Statistics," and the "Journal of the American Statistical Association - Theory and Methods."
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Alessandra Mattei is Professor of Statistics at the Department of Statistics, Computer Science, Applications "G. Parenti"- DiSIA of the University of Florence. Her main research interest is causal inference from experimental and observational studies in various areas of science including social sciences, public policy, public health, environmental health, and biomedical sciences. She is also interested in missing data problems and Bayesian inference methods. She has published in various peer-reviewed journals. She is an associate editor of "Biometrical Journal," "The Annals of Applied Statistics," and the "Statistical Methods and Applications."
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Fabrizia Mealli and Alessandra Mattei have closely collaborated since Alessandra Mattei's PhD. They have worked together on numerous scientific projects and papers in causal inference and have collaborated in organizing conferences and international schools on causal inference. They also have shared teaching in international schools on causal inference.