Causal inference: foundation, application and assumptions (5 cr)

Responsible organisation: Master's Programme in Mathematics and Statistics
Responsible teacher for course unit: Ana Kolar
Course unit level: Advanced studies
Course unit type: Regular course unit
Possible attainment languages: English

Course Unit Information

Prerequisites

Studies in applied statistics and regression analysis.

Learning outcomes

By the end of this course, students become familiar with fundamental concepts to analyse causal relationships in a scientifically objective way. This includes introduction to the theory, thinking and methods for estimating causal effects and performing impact evaluations.

Learning materials

The course will alternate between lectures and discussions based on selected chapters from the following books:

- Freedman, D. (2009). Statistical Models and Causal Inference: A Dialogue with the Social Sciences. Cambridge: Cambridge University Press.
- Imbens, G., & Rubin, D. (2015). Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction. Cambridge: Cambridge University Press.
- Rosenbaum, P. (2017). Observation and experiment. An introduction to causal inference. Cambridge: Harvard University Press.

and selected papers shared during the classes.

Additional info

Target group

The course is intended for Master’s degree or PhD students in Statistics, Data Science and other disciplines who meet the required prerequisites and are interested in learning about analytical approaches to answer causal questions.

Teacher: Ana Kolar, PhD www.tarastats.com/about/#anakolar

Timing

7 days intensive course 11.08.2022 – 19.08.2022 (except Saturday and Sunday). With the following daily schedule:

11.15 – 13.00 Session 1 (lecture, discussion and short break)

13.00h – 13.45 Lunch break

13.45h – 15.30h Session 2 (lecture, discussion and short break)

Contents

This course provides an introduction to causal inference theory, methodology and thinking using experimental and observational data. We use examples from a variety of fields, such as, health, economics and public policy, to discuss complexities of causal effect studies and conclusion making.

Day 1-2: Causality, Causal Thinking and Scientific Design in Causal Inference

We look at causality from a philosophical and scientific perspective, and explore the science of causal thinking, with a particular interest to learn about the impact that causal thinking has on scientific inquiry.

We continue with the definition of *what is 'causal' in statistical terms* and introduce the *causal design.* We present Potential Outcomes and its crucial extension: the Rubin Causal Model. We show the important difference between observational and experimental data when it comes to analysing causal relationships.

Day 3-4: Casual Inference Requires Modern Statistical Thinking

The development of modern statistical science goes back to 20th century with classical contributions such as Student's t-test (1908), Fisher's randomisation (1925) and Rubin's Causal Model (Holland, 1986; Imbens&Rubin, 2010). These contributions had a profound impact on development of modern sampling theories, as also theories for handling missing data. The modern statistical science emphasizes the importance of a carefully designed study and for that matter requires from researchers to be familiar with statistical thinking needed in modern statistical science, i.e., modern statistical thinking.

During these two days, we explore *why causal inference without modern statistical thinking is not productive* (in terms of obtaining trustworthy data insights).
We start by introducing the key concepts of modern statistical thinking and continue with important contributions of the modern statistical science that have a significant impact on development of the modern statistical thinking. We put emphasis on aspects that are crucial to analysis of causal relationships, causal-effect studies and impact evaluations.

Day 5-6: Assumptions and Bias in Causal Inference

Due to assumptions playing a major role in causal inference: "*Causal inference without assumptions is mission impossible*", we make an effort to understand this profound limitation by discussing different types of biases, ways to control for, as also by looking at different approaches to Sensitivity Analysis of causal claims.

Day 7: Designing A Study – Causal Inference With Observational Data

During our last day, we make an attempt to design a causal inference study. The focus of these

classes is to think carefully about the causal design and its impact on analysis of data.

These classes serve as the beginning of the final assignment for this course. We review the course material and apply the knowledge to design a causal effect study with observational data.

Please note that this course's focus is solely on how to design a study, i.e. how to develop a causal design that warrants causal claims. Accordingly, this assignment does not not require a use of computer software, but rather a heavy use of a 'human mind' software.

Students have one month time to complete the assignment. An extension of this deadline is possible, but needs to be approved by the teacher.

Activities and teaching methods in support of learning

A deep-learning teaching approach. In-class exercises, group discussions, regular feedback and reading.

Assessment practices and criteria

Participation in all sessions is mandatory.

Daily in-class exercises: 30% of the final grade

Final assignment 70% of the final grade

Responsible person

Ana Kolar