Syllabus

Methods in Causal Inferences for health economic and medical research

Goal

To give an overview and understanding of recent developments in methods for causal inference. To provide skills and experience in applying methods for causal inference in practical research.

Content

The course will give an overview of recent topics in causal inference with an emphasis on using modern machine learning methods. The course consists of two parts. The first part consists of 8 lectures during Maj 9-10 2019 by Professor Guido Imbens, Stanford Graduate School of Business. The second part of the course consists of writing a term paper and applying methods discussed in class.

- The first lecture will cover some basic issues in causal inference from the potential outcome perspective, including the analysis of randomized experiments based on randomization inference.
- The second lecture will cover recent advances in experimental design, focusing particularly on multi-armed bandits and Thompson sampling, that are widely used in experimentation in online settings.
- The third and fourth lectures will discuss estimation of average treatment effects under unconfoundedness under modest number of covariates, and many covariates, respectively.
- The fifth lecture will consider estimation of: (1) average treatment effects conditional on covariates; and (2) optimal assignment policies exploiting heterogeneity in treatment effects.
- The sixth lecture will focus on synthetic control methods.
- The seventh lecture we discuss regression discontinuity methods.
- The last lecture will look at recent work on combining observational studies and randomized experiments.

After the lectures students will write a 3-5-page (double spaced) term paper with a proposal for a potential research project were some of the methods for causal inference discussed class are applied. It is important that the term paper describes the causal question of interest, and how the question can be answered methodologically and with which real-world data set.

In order to help students in their work, two seminars will be organized. In a first seminar, about a week after the lectures, students will present and discuss topics for their term paper. In a second seminar, about 4 weeks after the lectures, the student will present and discuss their term papers. Sophie Langenskiöld and Erik Grönqvist will teach at the seminars and be examiners.

Teaching

Lecture (8 x 1,5 hour)
Seminar (5 x 2 hours)

Examination

Hand in of a term-paper
Presentation of the term paper, and active participation, at the seminars.
Presence is required at 6 (of 8) lectures and at the seminars.

Course Literature

Background reading

Athey, Susan, and Guido W. Imbens. "The state of applied econometrics: Causality and policy evaluation." *Journal of Economic Perspectives* 31.2 (2017): 3-32.

1. Causal Inference and Randomized Experiments, Part I

(a) Holland, Paul W. "Statistics and causal inference." *Journal of the American statistical Association* 81.396 (1986): 945-960.
(b) Imbens, Guido W., and Donald B. Rubin. *Causal inference in statistics, social, and biomedical sciences*. Cambridge University Press, 2015.

2. Causal Inference and Randomized Experiments, Part II

(a) S. Scott (2010), "A modern Bayesian look at the multi-armed bandit," *Applied Stochastic Models in Business and Industry*, vol 26(6):639–658.
(b) M. Dimakopoulou, S. Athey, and G. Imbens (2017). "Estimation Considerations in Contextual Bandits." http://arXiv.org/abs/1711.07077.

3. Estimating Average Treatment Effects Under Unconfoundedness, Part I

(a) Imbens, Guido W., and Jeffrey M. Wooldridge. "Recent developments in the econometrics of program evaluation." *Journal of economic literature* 47.1 (2009): 5-86.

4. Estimating Average Treatment Effects Under Unconfoundedness, Part II

(a) Athey, Susan, Guido W. Imbens, and Stefan Wager. "Approximate residual balancing: debiased inference of average treatment effects in high dimensions." *Journal of the Royal Statistical Society: Series B* (Statistical Methodology) 80.4 (2018): 597-623.
(b) A. Belloni, V. Chernozhukov, and C. Hansen (2014) "High-dimensional methods and inference on structural and treatment effects." *The Journal of Economic Perspectives*, 28(2):29-50. http://pubs.aeaweb.org/doi/pdfplus/10.1257/jep. 28.2.29
(c) V. Chernozhukov, D. Chetverikov, M. Demirer, E. Duflo, C. Hansen, W. Newey, and J. Robins (2017, December) "Double/Debiased Machine Learning for Treatment and Causal Parameters." https://arxiv.org/abs/1608.00060.

5. Causal Inference: Heterogeneous Treatment Effects

(a) S. Athey and G. Imbens (2016) "Recursive Partitioning for Heterogeneous Causal Effects," *Proceedings of the National Academy of Sciences*.
(b) S. Wager and S. Athey (2017) "Estimation and inference of heterogeneous treatment effects using random forests." *Journal of the American Statistical Association* http://arxiv.org/abs/1510.04342
(c) S. Athey, Tibshirani, J., and S.Wager (2017, July) "Generalized Random Forests" http://arxiv.org/abs/1610.01271

6. Synthetic Control Methods and Matrix Completion

(a) S. Athey, M. Bayati, N. Doudchenko, G. Imbens, and K. Khosravi (2017) "Matrix Completion Methods for Causal Panel Data Models." http://arXiv.org/abs/1710.10251.
(b) J. Bai (2009), "Panel data models with interactive fixed effects." *Econometrica*, 77(4): 1229–1279.
(c) E. Cand`es and B. Recht (2009) "Exact matrix completion via convex optimization." *Foundations of Computational mathematics*, 9(6):717-730.

7. Regression Discontinuity Designs

(a) Imbens, G., and T. Lemieux, "Regression Discontinuity Designs: A Guide to Practice," *Journal of Econometrics*, (2008), 615-635.
(b) Imbens, G., and S.Wager, "Optimized Regression Discontinuity Designs," *Review of Economics and Statistics*.

8. Combining Experimental and Observational Data

(a) Athey, S., R. Chetty, G. Imbens, and H. Kang, "Estimating Treatment Effects using Multiple Surrogates: The Role of the Surrogate Score and the Surrogate Index," NBER Working Paper.
(b) Athey, S., R. Chetty, and G. Imbens, "Using Experimental Data to Improve Estimates Based on Observational Data"

Teachers

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Erik Grönqvist

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