Course outline „Causal inference and experimental research"

Lecturer: Dr. Lukas Fervers

Time and date:

29.09.2025; 09:30-15:30

06.10.2025; 09:30-15:30

13.10.2025; 09:30-15:30

27.10.2025; 09:30-15:30

03.11.2025; 09:30-15:30

Course outline

Many research questions in economics, social sciences and education research are causal in nature. For example, we are interested in the effect of education on income, we wish to know whether further training helps the unemployed get back to work, or we would like to know what is the best way to improve literacy skills among pupils and adults. However, drawing causal conclusions usually requires special research designs and statistical methods. This course provides an introduction to the fundamentals of causal inference and experimental research. We will start with a short discussion about the conceptional understanding of causality and causal effects as outlined in the potential outcome framework. Subsequently, we will cover a wide range of research designs that are commonly used for causal inference, including experimental designs/randomized trials, natural and quasi-experiments as well as instrumental variable estimation. Moreover, we will touch upon recent developments from the causal inference literature, particularly synthetic controls and machine learning.

The course consists of eight sessions of about 2-2.5 hours each. The session will usually start with a presentation/discussion of the basic ideas of the respective methods and designs. Subsequently, will discuss possible scenarios in which these methods might be applied as well as possible threats to validity. To further illustrate the methods, we will discuss research papers that apply these methods and/or conduct our own analyses in STATA/R.

Prerequisites

- Basic knowledge of STATA or R
- Basic skills in statistics
- **Read references listed in the sessions**

Session 1 – Intro

- Introduction of course participants and course aims
- Conceptional understanding of causality: the potential outcome framework
- Parameters of interest: Average treatment effect, Average treatment effect on the treated and conditional average treatment effects

Literature

- Imbens and Rubin (2015): chapter 1.

Session 2 – Experimental research

- Why to conduct experiments?
- Design of experiments and methods for analysis
- Threats to validity: Hawthorne effect, interference between units, post-treatment selection, non-compliance, non-response bias

Literature

- Angrist and Pischke (2009): chapter 2.
- Athey, S., & Imbens, G. W. (2017). The econometrics of randomized experiments. In *Handbook of economic field experiments* (Vol. 1, pp. 73-140). North-Holland.
- Peter, F., Spiess, C. K., & Zambre, V. (2021). Informing students about college: Increasing enrollment using a behavioral intervention?. *Journal of Economic Behavior & Organization*, 190, 524-549.

Session 3 & 4 – Natural experiments I: Regression Discontinuity Designs (RDDs)

- Basic idea of natural experiments
- Assumptions and threats to validity in RDDs
- Sharp and fuzzy RDDs
- Estimation and inference in RDDs

Literature

- Angrist and Pischke (2009): chapter 6.1.
- Lee, D. S., & Lemieux, T. (2010). Regression discontinuity designs in economics. *Journal of economic literature*, 48(2), 281-355.
- Saw, G., Schneider, B., Frank, K., Chen, I. C., Keesler, V., & Martineau, J. (2017). The impact of being labeled as a persistently lowest achieving school: Regression discontinuity evidence on consequential school labeling. *American Journal of Education*, 123(4), 585-613.

Session 5: Natural experiments II: Difference-in-Differences

- Research design and assumptions
- Implementation, estimation and inference
- Threats to validity
- Variations and further issues

Literature

- Angrist and Pischke (2009): chapter 5.
- Görlitz, K. (2010). The effect of subsidizing continuous training investments—evidence from German establishment data. *Labour Economics*, 17(5), 789-798.

Session 6: Instrumental variable estimation

- Idea and assumptions of instrumental variables (IVs)
- Implementation and estimation
- IVs in experiments and natural experiments

- Wooldridge, J.M. (2002). *Introductory Econometrics: A Modern Approach*. South Western College Pub. Chapter 15-15.3. (p. 461-480)
- Bettinger, E. P., & Long, B. T. (2010). Does cheaper mean better? The impact of using adjunct instructors on student outcomes. *The Review of Economics and Statistics*, 92(3), 598-613.

Session 7 & 8: Macro treatments: The synthetic control method

- Idea and possible areas of application
- Implementation, estimation and inference
- Threats to validity
- Recent developments
- Course wrap-up

Literature

- Abadie, A., Diamond, A., & Hainmueller, J. (2015). Comparative politics and the synthetic control method. *American Journal of Political Science*, *59*(2), 495-510.
- Abadie, A. (2021). Using synthetic controls: Feasibility, data requirements, and methodological aspects. *Journal of Economic Literature*, 59(2), 391-425.

Reference list

Abadie, A., Diamond, A., & Hainmueller, J. (2015). Comparative politics and the synthetic control method. *American Journal of Political Science*, *59*(2), 495-510.

Abadie, A. (2021). Using synthetic controls: Feasibility, data requirements, and methodological aspects. *Journal of Economic Literature*, 59(2), 391-425

Almond, D., Doyle Jr, J. J., Kowalski, A. E., & Williams, H. (2010). Estimating marginal returns to medical care: Evidence from at-risk newborns. *The quarterly journal of economics*, 125(2), 591-634.

Angrist, J. D., & Pischke, J. S. (2009). Mostly harmless econometrics: An empiricist's companion. Princeton university press.

Athey, S., & Imbens, G. W. (2017). The econometrics of randomized experiments. In *Handbook of economic field experiments* (Vol. 1, pp. 73-140). North-Holland.

Bettinger, E. P., & Long, B. T. (2010). Does cheaper mean better? The impact of using adjunct instructors on student outcomes. *The Review of Economics and Statistics*, 92(3), 598-613.

Büttner, B., & Thomsen, S. L. (2015). Are we spending too many years in school? Causal evidence of the impact of shortening secondary school duration. *German Economic Review*, 16(1), 65-86.

Clarke, D., Pailañir, D., Athey, S., & Imbens, G. (2023). Synthetic difference in differences estimation. arXiv preprint arXiv:2301.11859.

Görlitz, K. (2010). The effect of subsidizing continuous training investments—evidence from German establishment data. *Labour Economics*, 17(5), 789-798.

Imbens, G. W., & Rubin, D. B. (2015). *Causal inference in statistics, social, and biomedical sciences*. Cambridge University Press.

LaLonde, R. J. (1986). Evaluating the econometric evaluations of training programs with experimental data. The *American economic review*, 604-620.

Peter, F., Spiess, C. K., & Zambre, V. (2021). Informing students about college: Increasing enrollment using a behavioral intervention?. *Journal of Economic Behavior & Organization*, 190, 524-549.

Saw, G., Schneider, B., Frank, K., Chen, I. C., Keesler, V., & Martineau, J. (2017). The impact of being labeled as a persistently lowest achieving school: Regression discontinuity evidence on consequential school labeling. *American Journal of Education*, 123(4), 585-613.

Further reading

Abadie, A., Diamond, A., & Hainmueller, J. (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, A., & Gardeazabal, J. (2003). The economic costs of conflict: A case study of the Basque Country. *American economic review*, 93(1), 113-132.

Arkhangelsky, D., Athey, S., Hirshberg, D. A., Imbens, G. W., & Wager, S. (2021). Synthetic difference-in-differences. *American Economic Review*, 111(12), 4088-4118.

Blundell. R. & Costa-Dias. M. (2009). Alternative approaches to evaluation in empirical microeconomics. *Journal of Human Resources*, 44 (3), 565-640.

Calonico, S., Cattaneo, M. D., Farrell, M. H., & Titiunik, R. (2017). rdrobust: Software for regression-discontinuity designs. *The Stata Journal*, 17(2), 372-404.

Cattaneo, M. D., Jansson, M., & Ma, X. (2018). Manipulation testing based on density discontinuity. *The Stata Journal*, 18(1), 234-261.

Caughey, D., & Sekhon, J. S. (2011). Elections and the regression discontinuity design: Lessons from close US house races, 1942–2008. *Political Analysis*, 19(4), 385-408.

Cerulli, G. (2020). Nonparametric synthetic control using the npsynth command. *The Stata Journal*, 20(4), 844-865.

Chiang, H. D., Matsushita, Y., & Otsu, T. (2023). Regression adjustment in randomized controlled trials with many covariates. arXiv preprint arXiv:2302.00469.

Galiani, S., & Quistorff, B. (2017). The synth_runner package: Utilities to automate synthetic control estimation using synth. *The Stata Journal*, 17(4), 834-849.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2), 254-277.

Freedman, D. A. (2008a). On regression adjustments to experimental data. *Advances in Applied Mathematics*, 40(2), 180-193.

Freedman, D. A. (2008b). On regression adjustments in experiments with several treatments. *Annals of Applied Statistics* 2(1): 176-196.

Huebener, M., Kuger, S., & Marcus, J. (2017). Increased instruction hours and the widening gap in student performance. *Labour Economics*, 47, 15-34.

Lee, D. S. (2008). Randomized experiments from non-random selection in US House elections. *Journal of Econometrics*, 142(2), 675-697.

Lee, D. S. (2008). Randomized experiments from non-random selection in US House elections. *Journal of Econometrics*, *142*(2), 675-697

Lee D. S. 2009. Training, wages, and sample selection: Estimating sharp bounds on treatment effects. *Review of Economic Studies* 76: 1071–1102

McCrary, J. (2008). Manipulation of the running variable in the regression discontinuity design: A density test. *Journal of econometrics*, 142(2), 698-714.

Niederle, M., & Vesterlund, L. (2007). Do women shy away from competition? Do men compete too much?. *The quarterly journal of economics*, 122(3), 1067-1101.

Piepenburg, J. G., & Beckmann, J. (2022). The relevance of social and academic integration for students' dropout decisions. Evidence from a factorial survey in Germany. *European Journal of Higher Education*, 12(3), 255-276.

Wager, S., Du, W., Taylor, J., & Tibshirani, R. J. (2016). High-dimensional regression adjustments in randomized experiments. *Proceedings of the National Academy of Sciences*, 113(45), 12673-12678.

Wooldridge, J. M. (2021). Two-Way Fixed Effects, the Two-Way Mundlak Regression, and Difference-in-Differences Estimators. Available at SSRN: https://ssrn.com/abstract=3906345 or http://dx.doi.org/10.2139/ssrn.3906345

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data.* Boston: MIT press.

Yan, G., & Chen, Q. (2023). synth2: Synthetic control method with placebo tests, robustness test, and visualization. *The Stata Journal*, 23(3), 597-624.