EUROPEAN UNIVERSTIY INSTITUTE

Department of Political and Social Sciences

The Statistics of Causal Inference

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Motivation

> Whenever, looking at my watch, I see the hand has reached the figure X, I hear the bells beginning to ring in the church close by. But from the fact that the watch hands point to ten whenever the bells begin to ring, I have not the right to infer that the position of the hands of my watch is the cause of the vibration of the bells.
>
> Leo Tolstoy, *War and Peace*, trans. Constance Garnett (New York: Modern Library Classics, 2002), p. 939.

Do hospitals make people healthier? Is it a problem that more people die in hospitals than in bars? Does an additional year of schooling increase future earnings? Do parties that enter the parliament enjoy vote gains in subsequent elections? The answers to these questions (and many others which affect our daily life) involve the identification and measurement of causal links: an old problem in philosophy and statistics. To address this problem we either use experiments or try to mimic them by collecting information on potential factors that may affect both treatment assignment and potential outcomes. Customary ways of doing this in the past entailed the specification of sophisticated versions of multivariate regressions. However, it is by now well understood that causality can only be dealt with during the design, not during the estimation process. The goal of this course is to familiarize participants with the logic of casual inference, the underlying theory behind it and introduce research methods that help us approach experimental benchmarks with observational data. Particular emphasis is placed on how to use these methods in order to address historical questions. Why did Protestant countries flourish more than catholic ones? How did the European migrants integrate in the US throughout the 20th century? What is the effect of Nazi territorial control on patterns of resistance during the

WWII? While discussing these and other applications, we will also shed light on how to think about archival work under the prism of causal inference. Hence, this will be a much applied course, which aims at providing participants with ideas for strong research designs in their own work.

Content Summary and Learning Outcomes

The objective is to learn how statistical methods can help us to draw causal claims about phenomena of interest. Participants will be introduced into an authoritative framework of causal inference in social sciences, i.e. the potential outcomes framework. By the end of the course, students will be in position to:

1. critically read and evaluate statements about causal relationships based on some analysis of data;
2. apply a variety of design-based easy-to-implement methods that will help them draw causal inferences in their own research.
3. think about archival data under the logic of causal inference.

Either explicitly or implicitly, the goal of most empirical research is to interpret causally the co-occurrence of interesting phenomena. Addressing causality, however, has been notoriously difficult without the luxury of experimental data. This course will introduce you to methods that allow you to make convincing causal claims without working with experimental data. In the first part of the course, we will look at three such designs:

1. Difference-in-Differences estimation;
2. Instrumental Variables and;
3. Regression Discontinuity Design

For every method, the following structure will be employed: first, a running example will provide the motivation and intuition. We will then proceed with the formal identification derivation and finally we will focus on estimation strategies and robustness checks. For each method there will be a hands-on lab section, where we will apply these methods with real data.

In the second part of our course, we will also cover the following additional topics:

1. Matching;
2. Synthetic Control methods
3. Mediation

I will set a slack channel for the course, where we can discuss about the topics and where you can bring also questions about other topics that we may not end up covering in the course. We will not have the time to cover topic at the end which I would love to talk about: `attrition` and `bounds`. Do ask me about this towards the second part of the course.

Textbook Readings

Angrist, Joshua and Jörn-Steffen Pischke. 2009. Mostly Harmless Econometrics: An Empiricist's Companion, Princeton: Princeton University Press.

Morgan Stephen L. and Christopher Winship. 2007. Counterfactuals and Causal Inference: Methods and Principles for Social Research, Cambridge: Cambridge University Press.

Angrist, Joshua D., and Jörn-Steffen Pischke. Mastering'metrics: The path from cause to effect. Princeton University Press, 2014.

Gerber, Alan S., and Donald P. Green. Field experiments: Design, analysis, and interpretation. WW Norton, 2012.

A very in-depth, path-breaking and by now legendary contribution in this field is Judea Pearl's *Causality*. Feel free to go through the book if you are particularly interested in the topic and you want to invest on this. Before doing so, it is worth knowing that Pearl uses a different notation, coming from computer science (hence the extensive use of *do* in the notation) which is not what we will be using in the course. Pearl is among other things famous for introducing the `Directed Acyclic Graphs`, aka **DAGs**. We will briefly introduce them and discuss its key points. Doing so will help to shed light on how the framework differs from the one we will follow, namely the potential outcomes framework. In case *Causality* is far too complex, which is the case for most people, feel free to use Pearl's subsequent attempts to popularize these ideas, either with *Causal Inference in Statistics* or, most prominently, *The Book of Why*.

Design-specific articles and papers are shown below.

All classes take place every **Tuesday 9-11am**, except otherwise noted. Room TBC for now.

Timetable

Week 1

- Introduction to the Potential Outcomes Framework
  - Motivation, examples, discussion. We will see examples of the fundamental problem of causal inference. Introduction to the potential outcomes framework. We will derive the causal quantities of interest.
  - How experiments solve the fundamental problem of causal inference. The logic of randomization and why it works.

Readings:

- Angrist and Pischke: Ch. 1 & 2. Morgan and Winship Ch. 1 & 2.

Week 2

- Randomization given by nature: Examples of Natural Experiments
- Instrumental Variables: Intuition, Identification & Estimation, Wald Estimator, 2SLS Estimator

Readings:

- Angrist and Pischke: Ch. 4. Morgan and Winship Ch. 7.
- Angrist, Joshua, Guido Imbens, and Donal Rubin. "Identification of Causal Effects Using Instrumental Variables." *Journal of the American Statistical Association*, 91(434):444-55.
- Abadie, Alberto. 2003. Semiparametric Instrumental Variable Estimation of Treatment Response Models.*Journal of Econometrics*, 113: 231-63.
- Sovey, Allison & Donald Green. 2010. "Instrumental Variables Estimation in Political Science: A Readers' Guide." *American Journal of Political Science*, 55(1): 188-200.
- Imbens, Guido. 2014. Instrumental Variables: An Econometrician's Perspective. NBER Working Paper # 19983. [available Online here].
- Angrist, Joshua D. and Alan B. Krueger. 2001. Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments, *The Journal of Economic Perspectives*, 15(4): 69-85.
- Dunning, Thad. 2009. "Instrumental Variables." In Morlino et al. *International Encyclopedia of Political Science*, available online here.
- Acemoglu, Johnson, & Robinson. 2001. "The Colonial Origins of Comparative Development: An Empirical Investigation." *American Economic Review*, 91(5): 1369-1401, available online here.

- Lassen, David D. 2005. “The Effect of Information on Voter Turnout: Evidence from a Natural Experiment.” *American Journal of Political Science*, 49(1): 103-18.
- Dunning, Thad. Natural experiments in the social sciences: a design-based approach. Cambridge University Press, 2012.

Week 3

- Lab Session: Instrumental Variables
- Extension: Informing the compliers

Week 4

- Regression Discontinuity Design: Motivation, Identification, Estimation Strategies.
- Testing for Sorting, Robustness Checks, Examples, Applications.

Readings:

- Angrist & Pischke Ch. 6.
- Lee, David. “Randomized Experiments from Non-Random Selection in U.S. House Elections.” *Journal of Econometrics*, 142: 675-97.
- Imbens, Guido & Thomas Lemieux. 2007. Regression Discontinuity Designs: A Guide to Practice. NBER Working Paper, # 13039.
- Lee, David & Thomas Lemieux. Regression Discontinuity Designs in Economics, *Journal of Economic Literature*. 48:281-355.
- Hainmueller, Jens and Andrew Eggers. 2009. “MPs for Sale? Returns to Office in Postwar British Politics.” *American Political Science Review*, 103(04): 513-33.
- Dell, M. (2015). Trafficking networks and the Mexican drug war. *American Economic Review*, 105(6), 1738-79.
- Dell, M. (2010). The persistent effects of Peru’s mining mita. *Econometrica*, 78(6), 1863-1903.
- Ferwerda, J., & Miller, N. L. (2014). Political devolution and resistance to foreign rule: A natural experiment. *American Political Science Review*, 108(3), 642-660.
- Eggers, Andrew, Anthony Fowler, Jens Hainmueller, Andrew B. Hall, and James Snyder Jr. 2015. “On The Validity Of The Regression Discontinuity Design For Estimating Electoral Effects: New Evidence From Over 40,000 Close Races.” *American Journal of Political Science*,59(1):259-74, available online here.

Week 5

- The Fuzzy RD
- The Local Randomization Framework
- Extensions: Identification away from the Cut-off point & Randomization-Based Inference in the RD design.
- Lab Session: Regression Discontinuity Design

Readings:

- Angrist, Joshua D., and Miikka Rokkanen. "Wanna get away? RD identification away from the cutoff." (2013).
- Hainmueller, Jens, Andrew B. Hall, and James M. Snyder Jr. "Assessing the external validity of election RD estimates: An investigation of the incumbency advantage." The Journal of Politics 77.3 (2015): 707-720.
- Cattaneo, Matias D., Brigham R. Frandsen, and Rocio Titiunik. "Randomization inference in the regression discontinuity design: An application to party advantages in the US Senate." Journal of Causal Inference 3.1 (2015): 1-24.

Week 6

- Difference-In-Differences: Motivation, examples, identification, estimation.
- Threads to validity and examples.

Readings:

- Angrist & Pischke Ch. 5.
- David, C., & Krueger Alan, B. (1994). Minimum wages and employment: a case study of the fast-food industry in New Jersey and Pennsylvania. *American Economic Review*, 84(4), 772-793.
- Fouka, Vasiliki. "How do immigrants respond to discrimination? The case of Germans in the US during World War I." American Political Science Review 113.2 (2019): 405-422.
- Fouka, Vasiliki. "Forthcoming.“Backlash: The Unintended Effects of Language Prohibition in US Schools after World War I.”." Review of Economic Studies.

Week 7

- Extensions: Triple-Differences, Adding Lags and leads, Fixed-Effects, and Interactions; The staggered dif-in-difs problem.
- Lab Session: Difference-In-Differences

Readings:

- Cantoni, D. (2015). The economic effects of the Protestant Reformation: testing the Weber hypothesis in the German lands. *Journal of the European Economic Association*, 13(4), 561-598.
- Acemoglu, D., Cantoni, D., Johnson, S., & Robinson, J. A. (2011). The consequences of radical reform: The French Revolution. *American Economic Review*, 101(7), 3286-3307.
- Autor, David H. "Outsourcing at will: The contribution of unjust dismissal doctrine to the growth of employment outsourcing." Journal of labor economics 21.1 (2003): 1-42.
- Just watch these two videos.

Week 8

- Matching: Motivation, examples, identification, estimation. Genetic Matching and Entropy Balancing.
- Quick Lab session
  - Diamond and Sekhon 2013, "Genetic Matching for Estimating Causal Effects: A General Multivariate Matching Method for Achieving Balance in Observational Studies." Review of Economics & Statistics.
  - Rosenbaum, Paul R. 2002. Observational Studies. New York: Springer-Verlag 2nd edition.
  - Hainmueller, Jens. "Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies." Political Analysis 20.1 (2012): 25-46.

Week 9

- Synthetic Control: Motivation, examples, identification, estimation.
- Quick Lab session Readings:
  - Abadie, A., & Gardeazabal, J. (2003). The economic costs of conflict: A case study of the Basque Country. *American economic review*, 113-132.
  - Abadie, A., Diamond, A., & Hainmueller, J. (2012). Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. *Journal of the American Statistical Association*.
  - Abadie, A., Diamond, A., & Hainmueller, J. (2015). Comparative politics and the synthetic control method. *American Journal of Political Science*, 59(2), 495-510.

Week 10

- Mediation analysis and DAGs
- Introduction to Directed Acyclic Graphs
- The back-door criterion
- The front-door criterion
- What must be true for the strategy to work: pros and cons
- examples

Readings:

- Morgan and Winship, chs. 3 and 4
- Glynn, A. N. (2012). The product and difference fallacies for indirect effects. *American Journal of Political Science* 56(1), 257–269.
- Glynn, A., & Kashin, K. (2014). Front-door Difference-in-Differences Estimators. Manuscript. Harvard University, Cambridge, MA.
- Imai, Kosuke, et al. "Unpacking the black box of causality: Learning about causal mechanisms from experimental and observational studies." *American Political Science Review* (2011): 765–789.
- Acharya, Avidit, Matthew Blackwell, and Maya Sen. "Explaining causal findings without bias: Detecting and assessing direct effects." *American Political Science Review* 110.3 (2016): 512–529.

Data & Software

We will use `R` and `Stata` to present examples from published and unpublished articles for each of the four methods.

Assignments

Replicate one design-specific paper or use your own data to implement one of the methods we will learn. Deadline will be three weeks since the end of the course. We will say a lot more about this in the class.