

# POL 573 – SOC 595: Quantitative Analysis III

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## 1 Contact Information

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## 2 Logistics

Time: 15:00 – 16:20, Mondays and Thursdays.

Location: Wallace 006.

Course mailing list (to which all the questions about the lectures, problem sets, exams, and precepts should be addressed): :POL573-SOC595\_S2008@Princeton.Edu

## 3 Course Description

This year, the course will focus on the recent development of statistical methods for causal inference. I will begin by presenting the general statistical framework of causal inference based on potential outcomes and reviewing classical randomization inference for analyzing randomized experiments. I will also cover basic experimental designs including matched-pair design, randomized block design, and cluster randomization design. Various complications that commonly arise in randomized field experiments are also discussed. They include noncompliance, direct and indirect effects, missing data, and interference among units. The second half of the course will be devoted to the statistical design and analysis of observational data for causal inference. We first consider the methodological issues under the assumption of no confounding. In particular, we discuss matching, subclassification, and weighting methods based on propensity scores and their generalizations. We also consider several design strategies for observational research including regression discontinuity and difference-in-differences designs. The goal of this course is to familiarize students with basic ideas and techniques that are used in the statistical literature of causal inference so that they can improve their own empirical research and take a first step towards the development of new statistical methodology for causal inference.

## 4 Prerequisites

Intermediate applied statistics at the level of POL 572 and mathematical knowledge at the level of POL 502. If you are not sure whether you satisfy these prerequisites, please contact me.

## 5 Course Requirements

The final grades are based on problem sets and a final exam or project.

1. **Problem sets (50%).** I plan to give several problem sets during the semester, and each problem set will be equally weighted. Late submission is not allowed unless you obtain my permission. Although you are encouraged to form a study group and discuss the materials together, you should not simply copy someone else's computer code or write-ups.
2. **Final exam or project (50%).** Students can choose either a final paper or a final exam.
  - The final exam will be a three-hour closed-book exam and will be held on May 14.
  - The final paper is due 4pm on May 13 in my mailbox in the Department of Politics, Corwin Hall. Late submission is not allowed without my permission. Note that you are allowed to coauthor a paper with your fellow student in the class. Some of the final papers that past students wrote for this class have been published in peer review journals and won prizes at conferences.

## 6 Computation

In this course, we support statistical software, called **R**. **R** is available for any platform and without charge at <http://www.r-project.org/>. If necessary, we will hold precepts at the beginning of the semester to go over the basics of **R** programming. Although no support will be given, you are welcome to use other statistical software to complete the problem sets and the final project.

## 7 Books and Monographs

Although the course will be based on lectures and articles, you might find the following reference books useful.

- Causal Inference

Christopher H. Achen. *The Statistical Analysis of Quasi-experiments*. University of California Press, Berkeley, 1986.

Judea Pearl. *Causality: Models, Reasoning, and Inference*. Cambridge University Press, New York, 2000.

William R. Shadish, Thomas D. Cook, and Donald T. Campbell. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Houghton Mifflin, Boston, 2001.

Paul R. Rosenbaum. *Observational Studies*. Springer-Verlag, New York, 2nd edition, 2002.

Mark J. van der Laan and James M. Robins. *Unified Methods for Censored Longitudinal Data and Causality*. Springer, New York, 2003.

Donald B. Rubin. *Matched Sampling for Causal Effects*. Cambridge University Press, Cambridge, 2006.

Charles F. Manski. *Identification for Prediction and Decision*. Harvard University Press, Cambridge, MA, 2007.

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

- Probability, Statistics, and Econometrics

George Casella and Robert L. Berger. *Statistical Inference*. Duxbury, Pacific Grove, CA, 2nd edition, 2002.

Morris H. DeGroot and Mark J. Schervish. *Probability and Statistics*. Addison Wesley, Boston, 3rd edition, 2002.

Jeffrey M. Wooldridge. *Econometric Analysis of Cross Section and Panel Data*. The MIT Press, Cambridge, MA, 2002.

- R programming

Peter Dalgaard. *Introductory Statistics with R*. Springer Verlag, New York, 2002.

John Fox. *An R and S-plus Companion to Applied Regression*. Sage Publications, Thousand Oaks, CA, 2002.

## 8 Tentative Outline

The following is a list of potential topics to be covered in this course. Under each topic, I list a small number of theory and application articles, on which the lectures will be partially based. Some of the articles listed under “Theory” are quite technical, and hence students should treat the list as a collection of reference articles for each topic. Given the time constraint, the lectures will only be able to cover the basic ideas for each topic. Also, students want to find useful relevant chapters from Morgan and Winship (2007). The articles listed under “Application” are among the ones I am familiar with. There are many other applications that are better or worse in quality than those listed here.

### 8.1 Foundation

1. Statistical Framework of Causal Inference: Potential Outcomes and Principal Stratification

- Theory

Paul W. Holland. Statistics and causal inference (with discussion). *Journal of the American Statistical Association*, 81:945–960, 1986.

A. P. Dawid. Causal inference without counterfactuals (with discussion). *Journal of the American Statistical Association*, 95:407–424, 2000.

- Application

Junni L. Zhang and Donald B. Rubin. Estimation of causal effects via principal stratification when some outcomes are truncated by “death”. *Journal of Educational and Behavioral Statistics*, 28(4):353–368, 2003.

Macartan Humphreys, William A. Masters, and Martin E. Sandbu. The role of leaders in democratic deliberations: Results from a field experiment in São tomé and Príncipe. *World Politics*, 58:583–622, July 2006.

## 2. Design-based Analysis of Classical Randomized Experiments

For a very brief introduction on the differences between experiments and observational studies, read the first two chapters of the following book:

D. A. Freedman, R. Pisani, and R. A. Purves. *Statistics*. W. W. Norton, New York, 4th edition, 2007.

- Theory

J. Neyman. On the application of probability theory to agricultural experiments: Essay on principles, section 9. (translated in 1990). *Statistical Science*, 5:465–480, 1923.

Ronald A. Fisher. *The Design of Experiments*, chapter II. Oliver and Boyd, London, 1935.

Kosuke Imai, Gary King, and Elizabeth A. Stuart. Misunderstandings among experimentalists and observationalists about causal inference. *Journal of the Royal Statistical Society, Series A*, 171(2):481–501, March 2008.

- Application

Daniel E. Ho and Kosuke Imai. Randomization inference with natural experiments: An analysis of ballot effects in the 2003 california recall election. *Journal of the American Statistical Association*, 101(475):888–900, September 2006.

## 8.2 Causal Inference in Randomized Experiments

### 1. Noncompliance, Instrumental Variables, and Encouragement Design

- Theory

Joshua D. Angrist, Guido W. Imbens, and Donald B. Rubin. Identification of causal effects using instrumental variables (with discussion). *Journal of the American Statistical Association*, 91(434):444–455, 1996.

Alexander Balke and Judea Pearl. Bounds on treatment effects from studies with imperfect compliance. *Journal of the American Statistical Association*, 92:1171–1176, 1997.

- Application

Joshua D. Angrist. Lifetime earnings and the Vietnam era draft lottery: Evidence from social security administrative records. *American Economic Review*, 80:313–336, 1990.

## 2. Missing Data

- Theory

Constantine E. Frangakis and Donald B. Rubin. Addressing complications of intention-to-treat analysis in the combined presence of all-or-none treatment-noncompliance and subsequent missing outcomes. *Biometrika*, 86(2):365–379, 1999.

Joel L. Horowitz and Charles F. Manski. Nonparametric analysis of randomized experiments with missing covariate and outcome data. *Journal of the American Statistical Association*, 95(449):77–84, 2000.

- Application

Yusaku Horiuchi, Kosuke Imai, and Naoko Taniguchi. Designing and analyzing randomized experiments: Application to a Japanese election survey experiment. *American Journal of Political Science*, 51(3):669–687, July 2007.

## 3. Interference between Units and Cluster-Randomized Experiments

Michael E. Sobel. What do randomized studies of housing mobility demonstrate?: Causal inference in the face of interference. *Journal of the American Statistical Association*, 101(476):1398–1407, 2006.

Paul R. Rosenbaum. Interference between units in randomized experiments. *Journal of the American Statistical Association*, 102(477):191–200, 2007.

Tyler J. VanderWeele. Ignorability and stability assumptions in neighborhood effects research. *Statistics in Medicine*, In-press.

Kosuke Imai, Gary King, and Clayton Nall. The essential role of pair matching in cluster-randomized experiments, with application to the Mexican universal health insurance evaluation. Technical report, Department of Politics, Princeton University, 2007.

## 8.3 Causal Inference in Observational Studies

### 1. The Selection Problem and Design Considerations

- Theory

Donald T. Campbell. Reforms as experiments. *American Psychologist*, 24:409–429, 1969.

Charles F. Manski. Anatomy of the selection problem. *Journal of Human Resources*, 24(3):343–360, 1989.

Kosuke Imai, Gary King, and Elizabeth A. Stuart. Misunderstandings among experimentalists and observationalists about causal inference. *Journal of the Royal Statistical Society, Series A*, 171(2):481–501, March 2008.

- Application

Charles F. Manski and Daniel S. Nagin. Bounding disagreement about treatment effects: A case study of sentencing and recidivism. *Sociological Methodology*, 28:99–137, 1998.

## 2. Regression, Matching Methods, and the Role of Propensity Score

- Theory

Paul R. Rosenbaum and Donald B. Rubin. The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70:41–55, 1983.

Kosuke Imai and David A. van Dyk. Causal inference with general treatment regimes: Generalizing the propensity score. *Journal of the American Statistical Association*, 99(467):854–866, September 2004.

Guido W. Imbens. Nonparametric estimation of average treatment effects under exogeneity: A review. *Review of Economics and Statistics*, 86(1):4–29, 2004.

Daniel E. Ho, Kosuke Imai, Gary King, and Elizabeth A. Stuart. Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. *Political Analysis*, 15(3):199–236, Summer 2007.

- Applications

Rajeev H. Dehejia and Sadek Wahba. Causal effects in nonexperimental studies: Reevaluating the evaluation of training programs. *Journal of the American Statistical Association*, 94:1053–1062, 1999.

Alexis Diamond and Jasjeet Sekhon. Genetic matching for estimating causal effects: A new method of achieving balance in observational studies. Technical report, Harvard University, 2005.

Ben B. Hansen. Full matching in an observational study of coaching for the SAT. *Journal of the American Statistical Association*, 99(467):609–618, 2004.

## 3. Instrumental Variables

- Theory

Joshua D. Angrist and Guido W. Imbens. Two-stage least squares estimation of average causal effects in models with variable treatment intensity. *Journal of the American Statistical Association*, 90(430):431–442, 1995.

Charles F. Manski and John V. Pepper. Monotone instrumental variables: With an application to the returns to schooling. *Econometrica*, 68(4):997–1010, July 2000.

Guido W. Imbens and Paul R. Rosenbaum. Robust, accurate confidence intervals with a weak instrument: Quarter of birth and education. *Journal of the Royal Statistical Society, Series A*, 168(1):109–126, January 2005.

- Application

Joshua D. Angrist and Alan B. Krueger. Instrumental variables and the search for identification: From supply and demand to natural experiments. *Journal of Economic Perspectives*, 15(4):69–85, 2001.

#### 4. Regression Discontinuity Design

- Theory

Donald L. Thistlethwaite and Donald T. Campbell. Regression-discontinuity analysis: An alternative to the ex post facto experiment. *Journal of Educational Psychology*, 51(6):309–317, December 1960.

Jinyong Hahn, Petra Todd, and Wilbert Van der Klaauw. Identification and estimation of treatment effects with a regression-discontinuity design. *Econometrica*, 69(1):201–209, January 2001.

Guido W. Imbens and Thomas Lemieux. Regression discontinuity designs: A guide to practice. *Journal of Econometrics*, 142:615–635, 2008.

- Applications

Joshua D. Angrist and Victor Lavy. Using Maimonides’ rule to estimate the effects of class size on scholastic achievement. *Quarterly Journal of Economics*, 114(2):533–576, May 1999.

David S. Lee, Enrico Moretti, and Matthew J. Butler. Do voters affect or elect policies?: Evidence from the U.S. house. *Quarterly Journal of Economics*, 119:807–859, 2004.

#### 5. Difference-in-Differences and Before-and-After Designs

- Theory

Marianne Bertrand, Esther Duflo, and Sendhil Mullainathan. How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics*, 119(1):249–275, 2004.

Alberto Abadie, Alexis Diamond, and Jens Hainmueller. Synthetic control methods for comparative case studies: Estimating the effect of California’s tobacco control program. Technical report, Harvard University, Cambridge, MA, 2007.

- Applications

David Card and Alan Krueger. Minimum wages and employment: A case study of the fast-food industry in New Jersey and Pennsylvania. *American Economic Review*, 84(4):772–793, 1994.

Bruce D. Meyer. Natural and quasi-experiments in economics. *Journal of Business & Economic Statistics*, 13(2):151–161, April 1995.

Jasjeet S. Sekhon and Rocio Titiunik. Exploiting Tom DeLay: A new method for estimating incumbency advantage and the effect of candidate ethnicity on turnout. Technical report, University of California, Berkeley, 2007.