

The Statistics of Causal Inference in the Social Sciences
Political Science C236A
Statistics C239A

Professor Jasjeet Singh Sekhon

Class: 4-7pm Monday
200 Wheeler

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Description

Approaches to causal inference using the potential outcomes framework. Covers observational studies with and without ignorable treatment assignment, randomized experiments with and without noncompliance, instrumental variables, regression discontinuity, sensitivity analysis and randomization inference. Applications are drawn from a variety of fields including political science, economics, sociology, public health and medicine.

This course can be used to meet the Department's Methodology course-out option.

Prerequisites

At least one graduate matrix based multivariate regression course in addition to introductory statistics and probability. If you need to review material, please consult David Freedman's excellent *Statistical Models: Theory and Practice* or John Fox's *Applied Regression Analysis, Linear Models, and Related Methods*, which includes examples using the *R* programming language.

Evaluation

Final grades will be based on a series of homework assignments (30% of final grade), a midterm (30%), a term paper or final exam (30%), and class and section participation (10%). Student have the choice between a term paper and a final exam.

It is recommended that students write the term paper jointly with one or at most two other students. Experience has shown that this greatly facilitates learning as well as increases the likelihood that the paper will eventually become a published article.

Weekly readings and homework assignments are the norm. It is highly recommended that students form study groups in order to complete the homework assignments. Although it is recommended that people work together in order to complete the assignments, students must hand in their own individual answers. Photocopies and other reproductions of someone else's answers are not acceptable. Students should hand in the answers to the problem sets, and all computer code written to find those answers.

Incompletes: all course material must be handed in by the first day of class of the spring semester unless an exemption is explicitly granted.

Course Software and Books

The programming language for this course is the *R* variant of the *S* statistical programming language. It is available for download from: <http://www.r-project.org/>. *R* is open source software (released under the GNU public license) and is available at no charge. We will also be making extensive use of an R package called “Matching” (Sekhon In Press).

The three books listed below are required and available at various online bookstores and at the University Book Store.

- Rubin, Donald. 2006. *Matched Sampling for Causal Effects*. Cambridge University Press. ISBN 0521674360.
- Rosenbaum, Paul R. 2002. *Observational Studies*. Springer-Verlag. 2nd edition. ISBN 0387989676.
- Morgan, Stephen L. and Christopher Winship. 2007. *Counterfactuals and Causal Inference: Methods and Principles for Social Research*. Cambridge University Press. ISBN-10: 0521671930.
- Krause, Andreas and Melvin Olson. 2005. *The Basics of S-PLUS*. Springer. ISBN-10: 0387261095.

In addition to the required books, you may wish to obtain a copy of:

- Venables, W.N and Brian D. Ripley. 2003. *Modern Applied Statistics with S*. New York: Springer-Verlag. 4th edition. ISBN: 0387954570

Course outline

1. CAUSALITY

The potential outcomes framework for causal inference.

- Holland (1986) “Statistics and Causal Inference”

- Little and Rubin (2000) “Causal Effects in Clinical and Epidemiological Studies via Potential Outcomes”
- Sekhon (2004b): “Quality Meets Quantity: Case Studies, Conditional Probability and Counterfactuals”

Extra reading:

- Winship and Morgan (1999) “The Estimation of Causal Effects from Observational Data”

2. RANDOMIZED EXPERIMENTS AND CONTROLLING BIAS IN OBSERVATIONAL STUDIES

Properties of experiments, basic implementations, and illustrations of observational studies based on approximate experimental design.

- Neyman (1923 [1990]): “On the Application of Probability Theory to Agricultural Experiments. Essay on Principles. Section 9.” *Statistical Science* 5, 465–472.
- Rubin (2006) Chapters 1 and 2:
“William G. Cochran’s Contributions to the Design, Analysis and Evaluation of Observational Studies”
Cochran and Rubin (1973): “Controlling Bias in Observational Studies: A Review”
- Rosenbaum (2002b) Chapter 2

Extra readings:

- Przeworski (In Press) “Is the Science of Comparative Politics Possible?”
- Cox (1958): *Planning of Experiments*. Chapters 1 and 2.
- Cochran (1965): “The Planning of Observational Studies of Human Populations”
- Cochran (1983): Chapters 1 and 7

3. RANDOMIZATION INFERENCE

Fisherian and permutation Inference, and the Lady Tasting Tea

- Fisher (1935, ch 1–2): *Design of Experiments*
- Rosenbaum (2002b, ch 2): *Observational Studies*
- Rosenbaum (2002a): “Covariance adjustment in randomized experiments and observational studies.” *Statistical Science* 17 286–327 (with discussion).

Extra reading:

- Application to correct issues with weak instruments and 2SLS: Imbens and Rosenbaum (2005): “Randomization Inference with an Instrumental Variable,” *Journal of the Royal Statistical Society, Series A*, vol 168(1), 109–126.
- Attributable effects: Rosenbaum (2002b, 188–194).

4. Regression Adjustment to Experimental Data

- Freedman (2008a): “On regression adjustments to experimental data.”

- Freedman (2008c): “Randomization does not justify logistic regression”
 - Freedman (2008b): “On regression adjustments in experiments with several treatments”
5. UNIVARIATE MATCHING METHODS FOR CONTROLLING BIAS IN OBSERVATIONAL STUDIES
Experimental and observational studies where assignment to treatment is done on observables. Stratification and matching.
- Rubin (2006) Chapters 3 to 5:
 “Matching to Remove Bias in Observational Studies” Rubin (1973a)
 “The Use of Matched Sampling and Regression Adjustment to Remove Bias in Observational Studies” Rubin (1973b)
 “Assignment to a Treatment Group on the Basis of a Covariate”
 - Rosenbaum (2002b) Chapter 3.1–3.3
6. THE PROPENSITY SCORE
Logistic regression and the fundamentals of propensity score matching
- Handout on general linear models
 - Rubin (2006) Chapters 10, 11 and 14 all with Paul R. Rosenbaum:
 “The Central Role of the Propensity Score in Observational Studies” Rosenbaum and Rubin (1983)
 “Assessing Sensitivity to an Unobserved binary Covariate in an Observational Study with Binary Outcome”
 “The Bias Due to Incomplete Matching”
 - Morgan and Harding (2006): “Matching Estimators of Causal Effects: Prospects and Pitfalls in Theory and Practice”

Also see Rosenbaum and Rubin (1984); Rubin and Thomas (2000).

7. REGRESSION DISCONTINUITY DESIGN

- Thistlethwaite and Campbell (1960): “Regression-Discontinuity Analysis: An alternative to the ex post facto experiment”
- Lee (2008): “Randomized Experiments from Non-random Selection in U.S. House Elections”
- Hahn, Todd, and van der Klaauw (2001): “Identification and Estimation of Treatment Effects with a Regression-Discontinuity Design”

Extra reading:

- Dunning (2008): “Improving Causal Inference: Strengths and Limitations of Natural Experiments.” *Political Science Quarterly* 61(2):282–293 2008.

8. MULTIVARIATE MATCHING

Mahalanobis distance, Genetic Matching and Equal Percent Bias Reduction

- Rubin (2006) Chapters 8 and 9:
 “Bias Reduction Using Mahalanobis-Metric Matching” Rubin (1980)
 “Using Multivariate Matched Sampling and Regression Adjustment to Control Bias in Observational Studies” Rubin (1979)

- Diamond and Sekhon (2005): Genetic Matching for Estimating Causal Effects: A General Multivariate Matching Method for Achieving Balance in Observational Studies

9. GENETIC MATCHING

Automatic balance optimization, evaluating balance and the LaLonde controversy

- Sekhon (2006): “Alternative Balance Metrics for Bias Reduction in Matching Methods for Causal Inference”
- Diamond and Sekhon (2005): “Genetic Matching for Estimating Causal Effects: A General Multivariate Matching Method for Achieving Balance in Observational Studies
- LaLonde (1986) [JSTOR]
- Dehejia and Wahba (1999) [JSTOR]
- Smith and Todd (2001)

10. MATCHING EXAMPLES USING OBSERVATIONAL DATA

Please read the first three of the Political Science examples listed here and any of the others you find of interest. An effort has been made to obtain examples across fields which are pedagogically interesting.

Political Science

- Gordon and Huber: “The Effect of Electoral Competitiveness on Incumbent Behavior”
- Gilligan and Sergenti: “Evaluating UN Peacekeeping with Matching to Improve Causal Inference”
- Lenz and Ladd: “Exploiting a Rare Shift in Communication Flows: Media Effects in the 1997 British Election”
- Simmons and Hopkins (2005): “The Constraining Power of International Treaties: Theory and Methods”

Economics

- Galiani, Gertler, and Schargrodsky (2005): “Water for Life: The Impact of the Privatization of Water Services on Child Mortality”
- Imbens, Rubin, and Sacerdote (2001): “Estimating the Effect of Unearned Income on Labor Earnings, Savings, and Consumption: Evidence from a Survey of Lottery Players”
- Angrist (1998): “Estimating the Labor Market Impact of Voluntary Military Service Using Social Security Data on Military Applicants.”

Other

- Christakis and Iwashyna (2003): “The Health Impact of Health Care on Families: A matched cohort study of hospice use by decedents and mortality outcomes in surviving, widowed spouses”
- Rubin (2001): “Using Propensity Scores to Help Design Observational Studies: Application to the Tobacco Litigation”

11. INSTRUMENTAL VARIABLES (IV)

- Angrist and Krueger (2001): “Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments”

- Angrist, Imbens, and Rubin (1996) “Identification of Causal Effects Using Instrumental Variables”
- Heckman (1997) “Instrumental Variables: A Study of Implicit Behavioral Assumptions Used in Making Program Evaluations”

Application, and use of randomization inference to correct an issue:

- Imbens and Rosenbaum (2005): “Randomization Inference with an Instrumental Variable,” *Journal of the Royal Statistical Society, Series A*, vol 168(1), 109–126.
- Angrist and Krueger (1991): “Does compulsory school attendance affect earnings?” *QJE* 1991; 106: 979–1019.
- Bound, Jaeger, and Baker (1995): “Problems with Instrumental Variables Estimation when the Correlation Between the Instruments and the Endogenous Regressors is Weak,” *JASA* 90, June 1995, 443–450.

12. APPLICATION: FIXING BROKEN EXPERIMENTS AND A CONTROVERSY

- Gerber, Alan S. and Donald P. Green. 2000. “The Effects of Canvassing, Telephone Calls, and Direct Mail on Voter Turnout: A Field Experiment.” *American Political Science Review* 94(3): 653–663.
- Imai, Kosuke. “Do Get-Out-The-Vote Calls Reduce Turnout? The Importance of Statistical Methods for Field Experiments.” *American Political Science Review*
- Green and Gerber Reply
- Bowers, Jake and Ben Hansen. 2005. “Attributing Effects to A Cluster Randomized Get-Out-The-Vote Campaign.”

13. SYNTHETIC COHORTS

When good matches cannot be found: create a new unit

- Abadie and Gardeazabal (2003): “The Economic Costs of Conflict: a Case-Control Study for the Basque Country”

14. FULL AND OPTIMAL MATCHING

- Rosenbaum (1991, 1989)
- Hansen (2004)

15. SENSITIVITY ANALYSIS FOR HIDDEN BIAS AND OTHER HELPFUL SUGGESTIONS

16. APPLICATION: VOTING IRREGULARITIES

- Wand, Shotts, Sekhon, Walter R. Mebane, Herron, and Brady (2001): *The Butterfly Did It: The Aberrant Vote for Buchanan in Palm Beach County, Florida*
- Mebane and Sekhon (2004): *Robust Estimation and Outlier Detection for Overdispersed Multinomial Models of Count Data*
- Herron and Wand (2007): *Assessing Partisan Bias in Voting Technology: The Case of the 2004 New Hampshire Recount*
- Sekhon (2004a): *The 2004 Florida Optical Voting Machine Controversy: A Causal Analysis Using Matching*

References

- Abadie, Alberto and Javier Gardeazabal. 2003. "The Economic Costs of Conflict: a Case-Control Study for the Basque Country." *American Economic Review* 92 (1).
- Angrist, J and AB Krueger. 1991. "Does compulsory school attendance affect earnings?" *Quarterly Journal of Economics* 106: 979–1019.
- Angrist, Joshua D. 1998. "Estimating the Labor Market Impact of Voluntary Military Service Using Social Security Data on Military Applicants." *Econometrica* 66 (2): 249–288.
- Angrist, Joshua D., Guido W. Imbens, and Donald B. Rubin. 1996. "Identification of Causal Effects Using Instrumental Variables." *Journal of the American Statistical Association* 91 (434): 444–455.
- Angrist, Joshua D. and Alan B. Krueger. 2001. "Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments." *Journal of Economic Perspectives* 15 (4): 69–85.
- Bound, J., D. Jaeger, and R. Baker. 1995. "Problems with Instrumental Variables Estimation when the Correlation Between the Instruments and the Endogenous Regressors is Weak." *Journal of the American Statistical Association* 90: 443–450.
- Christakis, Nicholas A. and Theodore I. Iwashyna. 2003. "The Health Impact of Health Care on Families: A matched cohort study of hospice use by decedents and mortality outcomes in surviving, widowed spouses." *Social Science & Medicine* 57 (3): 465–475.
- Cochran, William G. 1965. "The Planning of Observational Studies of Human Populations (with discussion)." *Journal of the Royal Statistical Society, Series A* 128: 234–255.
- Cochran, William G. 1983. *Planning and analysis of observational studies*. New York: John Wiley and Sons. Edited posthumously by L. E. Moses and F. Mosteller.
- Cochran, William G. and Donald B. Rubin. 1973. "Controlling Bias in Observational Studies: A Review." *Sankhya*, Ser. A 35: 417–446.
- Cox, David R. 1958. *Planning of Experiments*. New York: Wiley.
- Dehejia, Rajeev and Sadek Wahba. 1999. "Causal Effects in Non-Experimental Studies: Re-Evaluating the Evaluation of Training Programs." *Journal of the American Statistical Association* 94 (448): 1053–1062.
- Diamond, Alexis and Jasjeet S. Sekhon. 2005. "Genetic Matching for Estimating Causal Effects: A General Multivariate Matching Method for Achieving Balance in Observational Studies." Working Paper.
- Dunning, Thad. 2008. "Improving Causal Inference: Strengths and Limitations of Natural Experiments." *Political Science Quarterly* 61 (2): 282–293.
- Fisher, Ronald A. 1935. *Design of Experiments*. New York: Hafner.
- Freedman, David A. 2008a. "On Regression Adjustments in Experiments with Several Treatments." *Annals of Applied Statistics* 2 (1): 176–196.

- Freedman, David A. 2008b. "On Regression Adjustments to Experimental Data." *Advances in Applied Mathematics* 40 (2): 180–193.
- Freedman, David A. 2008c. "Randomization Does not Justify Logistic Regression." *Statistical Science* 23 (2): 237–249.
- Galiani, Sebastian, Paul Gertler, and Ernesto Schargrodsky. 2005. "Water for Life: The Impact of the Privatization of Water Services on Child Mortality." *Journal of Political Economy* 113 (1): 83–120.
- Gilligan, Michael J. and Ernest J. Sergenti. 2008. "Evaluating UN Peacekeeping with Matching to Improve Causal Inference." *Quarterly Journal of Political Science* 3 (2): 89–122.
- Gordon, Sandy and Greg Huber. 2007. "The Effect of Electoral Competitiveness on Incumbent Behavior." *Quarterly Journal of Political Science* 2 (2): 107–138.
- Hahn, Jinyong, Petra Todd, and Wilbert van der Klaauw. 2001. "Identification and Estimation of Treatment Effects with a Regression-Discontinuity Design." *Econometrica* 69: 201–209.
- Hansen, Ben B. 2004. "Full Matching in an Observational Study of Coaching for the SAT." *Journal of the American Statistical Association* 99: 609–618.
- Heckman, James. 1997. "Instrumental Variables: A Study of Implicit Behavioral Assumptions Used in Making Program Evaluations." *The Journal of Human Resources* 32 (3): 441–462.
- Herron, Michael C. and Jonathan Wand. 2007. "Assessing Partisan Bias in Voting Technology: The Case of the 2004 New Hampshire Recount." *Electoral Studies* 26 (2): 247–261.
- Holland, Paul W. 1986. "Statistics and Causal Inference." *Journal of the American Statistical Association* 81 (396): 945–960.
- Imbens, Guido W. and Paul Rosenbaum. 2005. "Randomization Inference with an Instrumental Variable." *Journal of the Royal Statistical Society, Series A* 168: 109–126.
- Imbens, Guido W., Donald B. Rubin, and Bruce I. Sacerdote. 2001. "Estimating the Effect of Unearned Income on Labor Earnings, Savings, and Consumption: Evidence from a Survey of Lottery Players." *American Economic Review* 91 (4): 778–794.
- LaLonde, Robert. 1986. "Evaluating the Econometric Evaluations of Training Programs with Experimental Data." *American Economic Review* 76 (September): 604–20.
- Lee, David S. 2008. "Randomized Experiments from Non-random Selection in U.S. House Elections." *Journal of Econometrics* 142 (2): 675–697.
- Lenz, Gabriel S. and Jonathan McDonald Ladd. 2006. "Exploiting a Rare Shift in Communication Flows: Media Effects in the 1997 British Election." <http://sekhon.berkeley.edu/causalinf/papers/LaddLenzBritish.pdf>.
- Little, Roderick J. A. and Donald B. Rubin. 2000. "Causal Effects in Clinical and Epidemiological Studies via Potential Outcomes: Concepts and Analytical Approaches." *Annual Review of Public Health* 21: 121–145.

- Mebane, Walter R. Jr. and Jasjeet S. Sekhon. 2004. "Robust Estimation and Outlier Detection for Overdispersed Multinomial Models of Count Data." *American Journal of Political Science* 48 (2): 391–410.
- Morgan, Stephen L. and David J. Harding. 2006. "Matching Estimators of Causal Effects: Prospects and Pitfalls in Theory and Practice." *Sociological Methods & Research* 35 (1): 3–60.
- Neyman, Jerzy. 1923 [1990]. "On the Application of Probability Theory to Agricultural Experiments. Essay on Principles. Section 9." *Statistical Science* 5 (4): 465–472. Trans. Dorota M. Dabrowska and Terence P. Speed.
- Przeworski, Adam. In Press. "Is the Science of Comparative Politics Possible." In Carles Boix and Susan C. Stokes, editors, *Oxford Handbook in Comparative Politics* New York: Oxford University Press.
- Rosenbaum, Paul R. 1989. "Optimal Matching for Observational Studies." *Journal of the American Statistical Association* 84 (408): 1024–1032.
- Rosenbaum, Paul R. 1991. "A Characterization of Optimal Designs for Observational Studies." *Journal of the Royal Statistical Society, Series B* 53 (3): 597–610.
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- Rosenbaum, Paul R. and Donald B. Rubin. 1984. "Reducing Bias in Observational Studies Using Subclassification on the Propensity Score." *Journal of the American Statistical Association* 79 (387): 516–524.
- Rubin, Donald B. 1973a. "Matching to Remove Bias in Observational Studies." *Biometrics* 29: 159–184.
- Rubin, Donald B. 1973b. "The Use of Matching and Regression Adjustment to Remove Bias in Observational Studies." *Biometrics* 29: 185–203.
- Rubin, Donald B. 1979. "Using Multivariate Sampling and Regression Adjustment to Control Bias in Observational Studies." *Journal of the American Statistical Association* 74: 318–328.
- Rubin, Donald B. 1980. "Bias Reduction Using Mahalanobis-Metric Matching." *Biometrics* 36 (2): 293–298.
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