Soc 952: Causality
Mathematical and Statistical Applications in Sociology
Spring 2011
Time: Thursdays 2:30-5:30
Room 1510, Microbial Science

Professor: Felix Elwert
Office Hours: Wed 4:15-5:15 and by appointment
Location: 4426 Sewell Social Science Building
Phone: (608) 262-9510
Email: felwert@ssc.wisc.edu (preferred)

Course Description
Social scientists routinely ask causal questions. "Does job training cause higher earnings?" "Does divorce impede children's academic progress?" "Does the death of a husband raise the mortality of a surviving wife?" Questions such as these are as old as the discipline. And yet, social scientist used to retreat behind the dictum "correlation does not equal causation" (true as it is) to disavow the causal ambition of their empirical analyses.

Building on seminal work by statistician Donald Rubin in the 1970s, among others, researchers today have at their disposal a powerful framework to conceptualize and implement causal inference. This framework, known as the *counterfactual model*, or *potential-outcomes framework of causal inference*, has over the past decade become the dominant model of causal inference in the social and health sciences. It takes up previous developments in statistics, econometrics, and experimental data analysis to unite parallel efforts under a common roof.

A central appeal of the counterfactual framework is its simplicity and generality. In keeping with common intuition, it conceptualizes causal questions as "what-would-happen-if" questions, and causal effects as the difference between potential outcomes associated with alternative treatments.

The counterfactual framework, however, is not primarily a collection of techniques, such as those commonly taught in specialized courses on survival analysis, multilevel models, or time-series analysis. What defines those techniques is a common data structure (e.g. time-to-event data, hierarchical data, repeated grouped observations over time). The counterfactual framework, by contrast, does not specialize in a particular data structure, but in a particular type of question—causal questions—that cuts across applications. The counterfactual model investigates the conditions under which causal inference is possible and provides guidance for estimating causal effects in practice.

Consequently, the counterfactual framework is credited with inventing relatively few genuinely new statistical techniques. Instead, it is appreciated for improving our understanding of existing techniques—such as matching, regression, instrumental variables analysis—and advancing their use for new, causal, purposes. (That being said,

the counterfactual model is indeed associated with some important new techniques, such as propensity score estimation, g-estimation, and inverse-probability-of-treatment weighting, some of which we will encounter in this course.)

This course provides a broad introduction to the potential outcomes (counterfactual) framework of causal inference. Topics include methods developed in statistics, biostatistics, and economics: causal inference for point treatments using matching, propensity scores, and causal inference for time-varying treatments using inverse probability weighting in marginal structural models. We will consider complementary approaches to the problem of unobserved heterogeneity such as instrumental variables estimation and sensitivity analysis. And we will consider the identification of causal effects in complex causal systems using directed acyclic graphs.

Throughout, we will focus on the *conceptual logic* of these methods by developing solid substantive intuition and studying empirical applications. We will focus first on the difficulty of formulating and articulating coherent causal questions, and then consider suitable methods for answering them.

A word of warning: A central contribution of the counterfactual framework of causality is to spotlight implicit assumptions and inherent limitations in existing techniques. Consequently, many methodologists embrace the lessons of the new literature on causality as a call for analytic modesty. This may be discouraging to you at first. Yet an improved understanding of current limitations also prepares the way for novel solutions that stand on firmer ground than previous practice. We will encounter numerous such solutions in this course. Nevertheless, *this course does not focus on hands-on practice* with canned software routines. Rather, the goal is to sensitize students to conceptual issues in applied work, and to develop guiding intuitions that may empower the independent study of appropriate techniques for own empirical research projects.

Class structure
Class meetings will divide into lecture presentations of the technical material and student presentations of the empirical applications from the required readings (not necessarily in this order, as appropriate).

Enrollment
This course is limited to regularly enrolled students. Auditors must demonstrate a compelling reason against formal enrollment. Non-enrolled participants must contribute in the same manner as enrolled students, and fulfill the same requirements (sans the term paper).

Requirements
Readings: You commit to completing all required readings prior to the class meeting, and will make an effort to look at some of the optional readings as well.

Abstracts: Every week, you will submit a one-page (single-spaced) abstract of one or two assigned readings of your choice. Every abstract has two parts. First, you will highlight

the key methodological insight from your readings and explain it in your own words. Second, you will offer reflections on the implications of this insight for some substantive topic in your area of interest, or for your own research. Please proof your abstracts for content, style, spelling, and grammar. Abstracts are due as pdf or .docx email attachments on Wednesday night.

Presentations: All participants will present assigned articles in class at various points throughout the semester. Schedule TBA.

Assignments: Students will complete 2-4 homework assignments, which I will tailor to the difficulties students may have with the material. We will discuss results in class.

Paper: You will write a term paper on a causal topic. The paper may be empirical or conceptual and should relate to the concerns of this class. I encourage you to develop an existing project, or thesis chapter, in a causal direction, but ask that you disclose the amount of previous work on the topic and elaborate on the specific revisions generated for this class. The paper must begin with posing a well-defined question, or struggle to render an existing question causally precise. A one-page proposal for the paper is due by the 7th week of class. Please submit your papers as pdf files, not exceeding 20 double-spaced pages, 12 point font, one-inch margin, including tables, figures, and references. I will stop reading after 20 pages. Papers are due on May 13 (absolutely no extensions).

Grading
20% participation, 10% abstracts, 20% homework assignments, 70% final paper.

Prerequisites
Students should bring a solid understanding of standard regression methods for continuous and categorical outcomes at the level of Soc 361 and Soc 362 or above. Knowledge of basic probability theory is helpful but not strictly required, ditto calculus.

A note on reading statistics
There is real pleasure in reading statistics—but reading statistics is a different beast from reading applied work in sociology. Most of the methodological articles on the syllabus are best read *slowly* with pencil and paper. Note the definitions of all symbols as they first appear in the text for your reading reference. Then scan for the central insight explained in the text. Then understand how the accompanying equations cement the insight. Then figure out how the author arrives at the insight. Lastly, attempt to transfer the abstract insights of the readings to concrete applications in your own research by searching for a homologous problem in a substantive area that you understand well.

Don't be tricked by low page counts. A fruitful reading of 10 pages of introductory statistics may require anywhere between 2-10 hours of work. You'll often skip back and forth in an article to remind yourself of previous steps in a deductive chain, and you'll find yourself wanting to reread the entire thing once you've finally made it through for the first time.

It's impossible to skim the assigned readings an hour before class.

Required Text

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

This is the first comprehensive survey of the counterfactual approach to causal inference, written for a social science audience with a strong emphasis on causal thinking over mathematical derivations. This book provides the backbone for about two thirds of this course and constitutes the core of the required readings.

More Books on Causal Inference

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

An excellent and very accessible textbook exposition of the counterfactual interpretation of standard econometric tools (i.e. regression, IV, fixed effects, RD). You should probably buy this text and read it in parallel with Morgan and Winship.

Pearl, Judea. 2009. Causality, 2nd edition. Cambridge. Cambridge University Press.

An emerging classic: a comprehensive advanced treatment of directed acyclic graphs and their relationship to the potential outcomes model and structural equation models. For what it does, this is a surprisingly accessible book, requiring only a moderate background in probability theory and formal logic.

Manksi, Charles F. 2007. Identification for Prediction and Decision. Cambridge: Harvard University Press.

Similar material as Angrist and Pischke, somewhat more technical. Greater emphasis on prediction. The textbook follow up to Manski's classic *Identification Problems in the Social Sciences* (Harvard, 2005)

Rosenbaum, Paul R. 2000. Observational Studies (2nd ed.). Springer Press.

The most thorough textbook on matching models for observational studies, written by one of the progenitors of counterfactualism. Densely written. Requires a solid working knowledge of intermediate probability theory.

Shadish, WR, TD Cook, and DT Campbell. 2001. Experimental and Quasi-Experimental Designs for Generalized Causal Inference. Houghton Mifflin.

Update on a classic text in psychology and sociology. Covers in detail situations in which completely randomized experiments are not feasible yet close substitutes are, given suitable assumptions. Introduced regression-discontinuity and interrupted-time-series designs to the field. Low tech style.

General Statistics Texts for Social Scientists

Gelman, Andrew, and Jennifer Hill. 2007. Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge: Cambridge University Press.

This treatment of standard regression and multilevel techniques has the potential of becoming the new textbook of record for intermediate social science statistics courses. It is exceptionally well written, focuses on underlying ideas over mathematical details, and seamlessly integrates numerous line-by-line software examples (in R). This book presents the material from a statistical, rather than econometric, perspective (which are often equivalent, despite considerable differences in terminology). We'll occasionally draw on this book for expositions, examples, and some exercises. Additionally, you may find this book useful to brush up on techniques encountered but not explained in Morgan and Winship and the assigned journal articles. You should probably own this book.

Wooldrige, Jeffrey M. 2001. Econometric Analysis of Cross Section and Panel Data. Cambridge: MIT Press.

An excellent comprehensive treatment of modern econometrics, a current favorite of advanced survey courses in econometrics. This book focuses more on mathematical detail and hence requires a solid working knowledge of multivariate calculus.

Schedule
(Subject to change!)

1. The Counterfactual Model

Required:
Holland, P. 1986. "Statistics and Causal Inference." Journal of the American Statistical Association, 81(396): 945-960. Read: 945-949, 954-955, 959.

Morgan, S. and C. Winship. 2007. Counterfactuals and Causal Inference: Methods and Principles for Social Research. Cambridge: Cambridge University Press. Read pp. 31-50.

Optional:

Morgan, S. and C. Winship. 2007. Read 1-30.

Gangl, Markus. 2009. "Causal Inference in Sociological Research" *Forthcoming in* Annual Review of Sociology 2010. Read: 1-13.

Angrist, JD, and JS Pischke. 2009. Mostly Harmless Econometrics. Chapters 1 & 2.

LaLonde, RJ. 1986. "Evaluating the Econometric Evaluation of Training Programs with Experimental Data." American Economic Review 74(4): 604-620.

Heckman, J. 2005. "The Scientific Model of Causality." Sociological Methodology 35(1): 1-98. Read Pp. 1-9.

2. Asking Causal Questions and Randomized Experiments

All Required except otherwise noted:

Asking Causal Questions:

Gelman, Andrew, and Jennifer Hill. 2007. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge: Cambridge University Press. Read Pp. 186-188.

Sobel, Michael. 2006. "Spatial Concentration and Social Stratification: Does the Clustering of Disadvantage 'Beget' Bad Outcomes?" Pp. 204-229 in S. Bowles, S.N. Durlauf, and K. Hoff (Eds.), Poverty Traps. New York: Russell Sage Foundation. Available at: http://www.sociology.columbia.edu/pdf-files/sobelspatial.pdf
You may find this article rather challenging. Work on it.

Assignment:

Assignment
Read Goldin and Crouse and submit it to causal scrutiny as exemplified by the two articles above. For example, ask yourself, what is the implied counterfactual; can you think of closely related counterfactual contrasts that may be of interest but that are not addressed in the study; can you determine what hypothetical experiment is being reconstructed; what potential policy intervention may the study inform; is SUTVA problematic in this study; would SUTVA be problematic if policy recommendations were derived from the study? How do the authors conceptualize the "effect of gender"? What other forms of "gender effects" may be of interest in the specific context of musical career achievement? How would you capture those; suggest hypothetical experiments.

Goldin, C, and Crouse. 2000. "Orchestrating Impartiality: The Impact of "Blind" Auditions on Female Musicians." American Economic Review 90(4):715-741

Experiments

Optional: Heckman, J, and JA Smith. (1995). "Assessing the Case for Social Experiments." Journal of Economic Perspectives 9: 85-110.

Required: Bertrand, M., and S. Mullainathan. 2004. "Are Emily and Greg More Employable Than Lakisha nad Jamal? A Field Experiment on Labor market Discrimination." American Economic Review 94(4): 991-1013.
One of my favorite articles these days. Aim to understand the logic behind every analytic move.

3. Directed Acyclic Graphs I

Required:
Morgan and Winship, Chapter 3

Greenland, Sander, Judea Pearl, and James M. Robins. 1999. "Causal Diagrams for Epidemiologic Research." Epidemiology 10(1):37-48.

Optional:
Judea Pearl. 2010. "The Foundations of Causal Inference." Sociological Methodology. Vol. 40: 75-150.
Great. Future lectures will draw heavily on this, albeit less technically.

Robins, JM. 2001. "Data, Design, And Background Knowledge in Etiologic Inference." Epidemiology 12:313-320.
Similar to Greenland et al 1999. Lots of examples. Merits slow and careful reading.

Pearl, J. 1995. "Causal Diagrams for Empirical Research." *Biometrika,* 82(4):669-710. Read: 669-688.

This is a classic. I've put an excerpt from Pearl's book on the course website that explains "d-separation without tears" (Pearl's title), which you may find helpful.

4. DAGs II: Endogenous Selection

Required:
Morgan and Winship, Pp. 179-181 (on controlling for pretests)

Optional:
VanderWeele TJ, Hernán MA, Robins JM. (2008). Causal Directed Acyclic Graphs and the Direction of Unmeasured Confounding Bias. Epidemiology 19(5):720-728.

Elwert, F, and C Winship 2008. "Endogenous Selection Bias." Unpublished Manuscript.

Rosenbaum, Paul. 1984. "The Consequences of Adjustment for a Concomitant Variable that has been Affected by the Treatment." Journal of the Royal Statistical Society, Series A, 147:656-666.

Gelman and Hill, 2007. Read: 188-194

5. Matching I

Required:
Morgan and Winship, Chapter 4

Rosenbaum and Rubin. 1984. "Reducing Bias in Observational Studies Using Subclassification on the Propensity Score." Journal of the American Statistical Association 79: 516-24.

Dehejia and Wahba. (1999). "Causal Effects in Nonexperimental Studies: Reevaluating the Evaluation of Training Programs." Journal of the American Statistical Association 1053-62.

Recommended:
Rosenbaum and Rubin. 1983. "The Central Role of the Propensity Score in Observational Studies for Causal Effects." Biometrika 70: 41-55.

6. Matching II

Required:
Imai, K, G King, and EA Stuart. 2008. "Misunderstandings Between Experimentalists and Observationalists about Causal Inference." Journal of the Royal Statistical Society, Ser. A 171(2):481-502.

Ho, DE, K Imai, G King, EA Stuart. 2007. "Matching as Non-parametric Preprocessing for Reducing Model Dependence in Parametric Causal Inference." Political Analysis 15: 199-236.

Morgan. (2001). "Counterfactuals, Causal Effect Heterogeneity, and the Catholic School Effect on Learning." Sociology of Education 74: 341-374.

Optional:
Abadie, Alberto, David Drukker, Jane Leber Herr, and Guido W. Imbens. 2004. "Implementing Matching Estimators for Average Treatment Effects in Stata." Stata Journal 4(3): 290-311.

Angrist, JD. 1998. "Estimating the Labor Market Impact of Voluntary Military Service Using Social Security Data on Military Applicants." Econometrica 66(2):249-288. Read parts relating to matching example (interspersed throughout).

Matchit documentation (course website)

7. Regression

Required:
Morgan and Winship: Chapter 5.

Optional:
Elwert, F, and C Winship. 2010. "Effect Heterogeneity and Bias in Main-Effects-Only Regression Models." *Forthcoming.*

Angrist and Pischke. 2009. Mostly Harmless Econometrics. Chapter 3.

Freedman, DA. 1983. "A Note on Screening Regression Equations." American Statistician 37:152-5.

Paper proposals due in class.

8. Bounds and Sensitivity Analysis
Required:
Morgan and Winship, Pp. 169-179 (on Manski bounds)

Harding. (2003). "Counterfactual Models of Neighborhood Effects: The Effect of Neighborhood Poverty on Dropping out and Teenage Pregnancy." American Journal of Sociology 109: 676-719. Skim entire and carefully read 691-694 and 700-712.

Greenland, S. 1996. "Basic Methods for Sensitivity Analysis of Biases." International Journal of Epidemiology. 25(6): 1107-1116.

Basic ideas presented out with great clarity. Uses epi lingo. Read this, then try Rosenbaum and Rubin 1983, which I will use in class.

Rosenbaum and Rubin. 1983. "Assessing Sensitivity to an Unobserved Binary Covariate in an Observational Study with Binary Outcome." Journal of the Royal Statistical Society, Ser. B 45: 212-218.

The original R&R exposition of sensitivity analysis. Basis of Harding 2003. Warrants careful reading. Hard. Give it a shot.

Rosenbaum. (1987). "The Role of a Second Control Group in an Observational Study (with Discussion)." Statistical Science 2: 292-316. Read pp292-302.

For substantially the same material, with less technical exposition, read Rosenbaum. 2002. Observational Studies (second edition). Chapter 8.

Optional:
Elwert, F, and NA Christakis. 2008. "Wives and Ex-wives: A New Test for Homogamy Bias in the Widowhood Effect." Demography. 45(4):

9. Instrumental Variables I (technical introduction)
Required:
Morgan and Winship, Pp. 181-184 and Chapter 7

Angrist, J, G. Imbens, and D. Rubin. (1996). "Identification of Causal Effects Using Instrumental Variables." Journal of the American Statistical Association 91: 444-455.

10. Instrumental Variables II (applications)
Morgan and Winship, Chapter 8-8.2

Angrist, J. 1990. "Lifetime Earnings and the Vietnam Era Draft Lottery: Evidence from Social Security Administrative Records." American Economic Review 80(3): 313-336.

Angrist, J. 1990. "Errata: Lifetime Earnings and the Vietnam Era Draft Lottery: Evidence from Social Security Administrative Records." The American Economic Review80(5): 1284-1286.

Bedard, K, and Olivier Deschênes. 2005. "Sex Preferences, Marital Dissolution, and the Economic Status of Women." The Journal of Human Resources, 40(2): 411-434.

Angrist, JD, and Alan B. Krueger. 1991. Does Compulsory School Attendance Affect Schooling and Earnings? The Quarterly Journal of Economics, 106(4): 979-1014.

Optional:
Rosenzweig and Wolpin. 2000. "Natural 'Natural Experiments' in Economics." Journal of Economic Literature 38: 827-74.
Read sections 1-3, focusing on examples discussed in Morgan and Winship, Ch 8.

Altonji, JG, Todd E. Elder, Christopher R. Taber. 2005. "An Evaluation of Instrumental Variable Strategies for Estimating the Effects of Catholic Schooling." The Journal of Human Resources, 40(4): 791-821.

11. Regression Discontinuity and Interrupted Time Series

Required:
Morgan and Winship, Chapter 9 (only ITS and RDD, panel optional)

Angrist, JD, and Victor Lavy. 1999. "Using Maimonides' Rule to Estimate the Effect of Class Size on Scholastic Achievement." The Quarterly Journal of Economics, 114(2): 533-575.

Groger, J., and G. Ridgeway. 2006. "Testing for Racial Profiling in Traffic Stops From Behind a Veil of Darkness." JASA 101(475): 878-887.

Another, simple, RDD application, TBD

Rogger and Ridgeway 2006

Optional:
Imbens, G.W., Lemieux, T. 2007. "Regression discontinuity designs: A guide to practice." Journal of Econometrics.

Angrist and Pischke. 2008. Chapter 6

Lee, D.S., and T Lemieux. 2009. "Regression Discontinuity Designs in Economics." NERB working paper. http://papers.nber.org/papers/W14723

Braga et al 2001 Evaluation.

12. [TBD]

13. Direct and Indirect Effects

Required:
Pearl, J.. 2005. "Direct and Indirect Effects." JSM Proceedings: 1572-1581.

Optional:
Gelman, Andrew, and Jennifer Hill. 2007. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge: Cambridge University Press. Read Pp. 189-194 for an introduction to Frangakis & Rubin's principal stratification framework.

VanderWeele, TJ 2008. "Simple relations between principal stratification and direct and indirect effects." Statistics & Probability Letters 78:2957–2962.

Robins, JM, and Greenland, S. 1992. "Identifiability and exchangeability for direct and indirect effects." Epidemiology 3(2):143–155.

14. Inference for Time Varying Treatments
Required:
Robins, JM. 1999. "Marginal Structural Models." Synthese.

Sharkey, P., and F Elwert. 2011. Multigenerational Neighborhood Effects on Child Cognition. American Journal of Sociology (forthcoming).

Optional:
Cole, SR, and MA Hernan. 2008. "Constructing Inverse Probability Weights for Marginal Structural Models." American Journal of Epidemiology.

Fewell, Z, MA Hernan, F Wolfe, K Tilling, H Choi, and JAC Sterne. (2004). "Controlling for time-dependent confounding using marginal structural models." The Stata Journal 4(4):402-420.

Sharkey, P, and F Elwert. 2009. "Multigenerational Effects of Neighborhood Disadvantage on Children's Cognitive Ability." Unpublished manuscript.

Hernán M, Brumback B, Robins JM. (2000). Marginal structural models to estimate the causal effect of zidovudine on the survival of HIV-positive men. Epidemiology, 11(5): 561-570.

VanderWeele, T.J. (2009). Marginal structural models for the estimation of direct and indirect effects. Epidemiology, 20:18-26.

15. Student Paper Presentations

10-15 minute presentations on each student final paper project.

- Clearly present the question or problem that you are working on.
- Explain the statistical means by which you will address the problem, or the theoretical or conceptual insight that you intend to exploit.
- State the definition of your population, your treatment, and your estimand (but do not dwell on data preparation issues—these are important for your paper, but near impossible to engage in a short presentation).
- All presentations should be accompanied by a one-page handout listing the key points of your presentation. Pictures are often helpful.
- At the end of the presentation, the audience should have a good idea about the key idea that you are trying to engage.

Final Papers due May 13