# Introduction to Causal Inference

## Spring 2016

Keio University

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| **Instructor:** | Teppei Yamamoto |
| **Email:** | teppei@mit.edu |
| **Class Time:** | July 14–16 and 18, Periods 2–4; July 19, Periods 3–4 |
| **Class Room:** | South Building, Floor 7, Room 471 |
| **Office Hours:** | July 14–16, 18 and 19, 4:30–5:30PM |

## Purpose and Goals

This intensive short course provides a survey of empirical methods used for causal inference in political science research. We cover a variety of research designs and statistical methods for causal inference, including randomized experiments, matching, regression, sensitivity analysis, nonparametric bounds, instrumental variables, regression discontinuity, difference-in-differences, and causal mediation analysis. We analyze the strengths and weaknesses of these methods. Applications are drawn from various fields in social science, including political science, public policy, economics and sociology.

## Prerequisites

There is no prerequisite for this class, but some prior exposure to basic probability theory and statistics will help you understand the materials better. Experience with real social science data, using regression models and preferably in R, will make you an ideal target of this course. However, any student with interest and motivation is welcome to participate in the course.

## Requirements

The final grades will be determined based on the following requirements:

- **Class attendance, participation and engagement** (10%): This course is taught within a short period and we will cover a broad range of materials at a fast pace. Therefore, your strong commitment and participation in each class is essential. Don't miss a class or you will be totally lost! Your active participation during class is also important and counts towards your grade. Here are some notes regarding what to expect:

- You may interrupt me at any point for clarification or a question during my lecture. If any questions or ideas occur to your mind, don't wait until the end of the class and come to me; I would rather you speak up during the class and share what you have to say with everyone else in the class.
- During my lecture I will occasionally ask questions to the class. Try and be the first one who responds, even if you are not 100% sure you know the correct answer. Saying something incorrect is far better than saying nothing at all.
- I understand that the class format is not ideal for a technical course like this one and that some people may find it difficult to stay perfectly concentrated throughout the four and half hours each day, even with breaks. Still, please try your best not to fall asleep during the class. If you do, I may ask you to leave the room. I also ask that you refrain from checking emails, Facebook, etc. during the class.

- **Problem sets** (30%): You can only learn statistics by doing statistics. Therefore, the homework for this course is extensive, including daily assignments. The assignments will consist of both analytical and data analysis questions, and they will be posted on the course website immediately after the last class on each day. There will be two types of problems: required and optional. Only the required problems will be due at the beginning of class next day, and performance on those will count towards your final grade. The optional questions are not directly included in grade calculation, although you are encouraged to complete them as your time permits. Due to the intensive nature of this course, I expect many of you to be unable to work on the optional problems. However, I strongly encourage you to come back to them during the summer vacation as review materials. Solutions for the problems, including the optional ones, will be posted immediately after they are due.

  Additional notes on problem sets:

  - Late submission will not be accepted unless you ask for special permission from me in advance of the deadline. (Permission may be granted or not granted, with or without penalty, depending on specific circumstances.)
  - Working in groups is encouraged, but you must submit your own write-up of the solutions. In particular, you must not copy and paste someone else's answers or computer code. We ask you to write down the names of the other students with whom you solved the problems together on the first sheet of your solutions.
  - For analytical questions, you should include your intermediate steps, as well as comments on those steps when appropriate. For computing and data analysis questions, include annotated code as part of your answers. All results should be presented so that they can be easily understood.

- **In-class quizzes** (30%): There will be a 20-minute closed-book quiz at the beginning of the first class each day (except on the first day). The quizzes will test your understanding of the materials covered up until the previous day, but naturally focus will be given to more recent materials.

- **Research proposal** (30%): For most of you the ultimate goal of taking this course should be to use the methods covered in the class for your own applied empirical research in political science or another field of social science. Therefore, the final assignment for this class will be a short research proposal (in place of a final exam or a term paper). Your proposal is due in one week after the class (i.e. **July 26**) and should meet the following formatting requirements:

  - Your proposal should be approximately 10 pages (12-point font, A4-sized paper) and written in English or Japanese.
  - Your proposal should look like a typical empirical journal article minus an actual empirical analysis. That is, the proposal should start with an abstract and consist of an introduction and sections on theoretical motivations, research design, data description, and statistical methodology.
  - The key section of your proposal will be the research design section, where you should focus on the discussion of your *identification strategy.* That is, you should explain, clearly and rigorously, what

assumptions have to be satisfied in order for your proposed research to produce a reliable estimate of a causal effect, and how and why your research design makes those assumptions likely to hold. Making a good argument for your identification strategy is an essential component of a good research proposal for this course.

- The theoretical motivation section should be concise and should not take up more than two pages of your proposal. In particular, you should avoid lengthy literature review. You should instead focus on the discussion of why your proposed research is interesting and important (not only to yourself but also to general audience in political science) clearly and succinctly.
- The data description section is optional and can be omitted if you do not already have a concrete dataset, data source, or specific mode of data collection in mind. However, even if you do not have any of those yet, you are encouraged to include a section or paragraphs discussing possible options for data collection to show that you are proposing a realistic empirical project that could actually be conducted with sufficient time and resource.

## Course Website

Course materials (lecture slides, problem sets, quiz questions, solutions, readings, etc.) will be posted on the course website, which can be accessed at:

http://web.mit.edu/teppei/www/teaching/Keio2016/index.html

## Notes on Computing

In this course, we will use R for the purpose of computation and data analysis. I expect that you will solve problem set questions using R. For those of you who are not familiar with the language, the first problem set will include questions that are designed to get you started with R.

## Books

- **Recommended books:** There is no single textbook for the course. However, many of the core materials are covered in the following book. The book is very popular among political scientists and applied economists and written in a relatively accessible fashion. I recommend that you purchase a copy. (Japanese translation is also available, but I recommend the original version, which is actually less expensive.)

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

  If you find the above book too technical, the same authors have also written a more accessible version of essentially the same book. (I use this one for my undergraduate causal inference class which assumes no prior knowledge on statistics or probability theory.)

  - Angrist, Joshua D. and Jörn-Steffen Pischke. 2015. *Mastering 'Metrics: The Path from Cause to Effect.* Princeton University Press.

  The following books cover materials in this course that are not discussed in the above two books. They are roughly at the same level of technicality as the first book but written from somewhat different perspectives which some methodologists find more appealing. These are not as essential as the first book, but still highly recommended for those who are interested in causal inference.

  - Morgan, Stephen L. and Christopher Winship. 2014. *Counterfactuals and Causal Inference: Methods and Principles for Social Research*, 2nd ed. Cambridge University Press.
  - Gerber, Alan S., and Donald P. Green. 2012. *Field Experiments*. W. W. Norton.

- **Optional books:** The following books are more advanced textbooks and monographs on causal inference. They go beyond the level of this course and not required for successfully completing the course. However, they are recommended for those of you who have stronger technical background and want to understand the materials more deeply.
  - Imbens, Guido W. and Donald B. Rubin. 2015. *Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction*. New York: Cambridge University Press.
  - Manski, Charles F. 1995. *Identification Problems in the Social Sciences*. Cambridge: Harvard University Press.
  - Pearl, Judea. 2009. *Causality: Models, Reasoning, and Inference*. New York: Cambridge University Press. 2nd edition.
  - Rosenbaum, Paul R. 2009. *Design of Observational Studies*. Springer Series in Statistics.
  - Wooldridge, Jeffrey M. 2002. Econometric Analysis of Cross Section and Panel Data. MIT Press.

# Course Outline

Note that recommended readings are in **bold**.

## 1 Statistical Models for Causal Analysis

Causality as counterfactuals, potential outcomes, the Fundamenal Problem of Causal Inference, identification and estimation, causal estimands, interference, causal graphs and other causal models, sufficient component causes

*Readings:*

- **Morgan and Winship: Chapters 1, 2 and 3.**
- **Angrist and Pischke: Chapter 1.**
- Sekhon, Jasjeet S. 2004. "Quality Meets Quantity: Case Studies, Conditional Probability and Counterfactuals." *Perspectives on Politics* 2(2): 281-293.
- Holland, Paul W. 1986. "Statistics and Causal Inference." *Journal of the American Statistical Association* 81(396): 945-960.
- Pearl, Judea. 1995. "Causal Diagrams for Empirical Research." *Biometrika*, 82(4): 779-710.
- Pearl, Judea. 2009. "Causal Inference in Statistics: An Overview." *Statistics Surveys*, 3: 96-146.
- Dawid, A. P. 2000. "Causal Inference Without Counterfractuals (with discussion)." *Journal of the American Statistical Association*, 95(450): 407-424.

# 2 Randomized Experiments

## 2.1 Identification and Estimation

Identification of causal effects under randomization, covariate adjustment, blocking, practical considerations

*Readings:*

- **Angrist and Pischke: Chapter 2.**
- **Gerber and Green: Chapters 2, 3 and 4.**
- 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.
- Freedman, D. A. 2008. "On Regression Adjustments to Experimental Data." *Advances in Applied Mathematics*, 40: 180-193.
- Lin, Winston. 2013. "Agnostic Notes on Regression Adjustments to Experimental Data: Reexamining Freedman's Critique." *Annals of Applied Statistics*. 7(5): 295-318.
- **Gerber, Alan S., Donald P. Green and Christopher W. Larimer. 2008. "Social Pressure and Voter Turnout: Evidence from a Large Scale Field Experiment." *American Political Science Review* 102(1): 1-48.**
- Olken, Benjamin. 2007. "Monitoring Corruption: Evidence from a Field Experiment in Indonesia." *Journal of Political Economy* 115(2): 200-249.
- Wantchekon, Leonard. 2003. "Clientelism and Voting Behavior: Evidence from a Field Experiment in Benin." *World Politics* 55(3), April: 399-422.
- Chattopadhyay, Raghabendra and Esther Duflo. 2004. "Women as Policy Makers: Evidence from a Randomized Policy Experiment in India." *Econometrica*, 72(5): 1409-1443.
- Hyde, Susan D. 2007. "The Observer Effect in International Politics: Evidence from a Natural Experiment." *World Politics* 60(1): 37-63.
- Ferraz, Claudio, and Federico Finan. 2008. "Exposing Corrupt Politicians: The Effects of Brazil's Publicly Released Audits on Electoral Outcomes." *Quarterly Journal of Economics* 123(2): 703-45.
- Washington, Ebonya L. (2008). "Female Socialization: How Daughters Affect Their Legislator Fathers' Voting on Women's Issues." *The American Economic Review*, 98(1), 311-332.
- Palfrey, Thomas. 2009. "Laboratory Experiments in Political Economy." *Annual Review of Political Science* 12: 379-388.
- Druckman, James N., Donald P. Green, James H. Kuklinski, and Arthur Lupia. 2006. "The Growth and Development of Experimental Research in Political Science." *American Political Science Review* 100(4): 627-635.
- Green, Donald P., Peter M. Aronow, and Mary C. McGrath. 2012. "Field Experiments and the Study of Voter Turnout." *Journal of Elections, Public Opinion & Parties*: 1-22.
- Humphreys, Macartan, and Jeremy Weinstein. 2009. "Field Experiments and the Political Economy of Development." *Annual Review of Political Science* 12: 367-378.
- Harrison, Glenn and John A. List. 2004. "Field Experiments." *Journal of Economic Literature*, XLII: 1013-1059.
- Levitt, Steven D. and John A. List. 2007. "What Do Laboratory Experiments Measuring Social Preferences Reveal About the Real World?" *Journal of Economic Perspectives* 21(2): 153-174.

- Gaines, Brian J., and James H. Kuklinski. 2007. "The Logic of the Survey Experiment Reexamined." *Political Analysis* 15: 1-20.
- Duflo, Esther, Rachel Glennerster, and Michael Kremer. 2006. "Using Randomization in Development Economics: A Toolkit." *Handbook of Development Economics*.
- Glennerster, Rachel and Kudzai Takavarasha. 2013. *Running Randomized Experiments: A Practical Guide*. Princeton University Press.

### 2.2 Inference

Neyman variance, clustered designs, randomization inference, bootstrap, power analysis

*Readings:*

- **Angrist and Pischke: Chapter 8.1**
- **Fisher, Ronald Aylmer. 1966 [1935]. *The Design of Experiments*. Edinburgh; London: Oliver and Boyd. Part II.**
- **Efron, Bradley, and R. J. Tibshirani. 1993. *An Introduction to the Bootstrap.* New York: Chapman and Hall/CRC. Chapters 2 and 6.**
- Rosenbaum, Paul R. 2010. *Design of Observational Studies*. Springer. Chapter 2.
- Ho, D. E. and K. Imai. 2006. "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.

## 3 Observational Studies

### 3.1 Identification

Selection on observables, post-treatment bias, subclassification

*Readings:*

- **Morgan and Winship: Chapter 4.**
- Rubin, Donald B. 2008. "For Objective Causal Inference, Design Trumps Analysis." *Annals of Applied Statistics* 2(3): 808-840.
- Rosenbaum, Paul R. 2002. Observational Studies. Springer-Verlag. 2nd edition. Chapter 3.
- Rosenbaum, Paul R. 1984. "The Consquences of Adjustment for a Concomitant Variable That Has Been Affected by the Treatment." *Journal of the Royal Statistical Society*. Series a (General), 147(5), 656-666.
- Cochran, W. G. 1968. The Effectiveness of Adjustment by Subclassification in Re-moving Bias in Observational Studies, *Biometrics*, vol. 24: 295-313.

### 3.2 Matching and Weighting

Covariate matching, balance checking, propensity scores

*Readings:*

- **Morgan and Winship: Chapter 5.**

- Ho, Daniel E., Kosuke Imai, Gary King, and Elizabeth A. Stuart. 2007. "Matching as Nonparametric Preprocessing for Reducing Model Dependence in Parametric Causal Inference." *Political Analysis* 15: 199-236.
- Stuart, Elizabeth A. 2010. "Matching Methods for Causal Inference: A Review and a Look Forward." *Statistical Science* 25(1):1-21.
- Imbens, Guido W. 2004. Nonparametric Estimation of Average Treatment Effects under Exogeneity: A Review. *Review of Economics and Statistics* 86 (1): 4-29.
- Abadie, Alberto and Guido W. Imbens. 2006. Large Sample Properties of Matching Estimators for Average Treatment Effects, *Econometrica* 74: 235-267.
- Abadie, Alberto, and Guido W. Imbens. 2011. "Bias-Corrected Matching Estimators for Average Treatment Effects." *Journal of Business & Economic Statistics* 29(1): 1-11.
- Imai, K., and D. A. van Dyk. 2004. Causal Inference With General Treatment Regimes. *Journal of the American Statistical Association*, 99(467), 854–866.
- Rubin, Donald. 2006. *Matched Sampling for Causal Effects*. Cambridge University Press. Chapters 3, 4, 5, 10, 11 and 14.
- Hirano, K., Imbens, G. W., and Ridder, G. 2003. Efficient Estimation of Average Treatment Effects Using the Estimated Propensity Score. *Econometrica*, 71(4), 1161-1189.
- Hainmueller, Jens. 2012. Entropy Balancing for Causal Effects: A Multivariate Reweighting Method to Produce Balanced Samples in Observational Studies. *Political Analysis* 20 (1): 25-46.
- Glynn, Adam, and Kevin Quinn. 2010. An Introduction to the Augmented Inverse Propensity Weighted Estimator. *Political Analysis* 18(1): 36-56.
- **Lyall, Jason. 2010. Are Co-Ethnics More Effective Counter-Insurgents? Evidence from the Second Chechen War. *American Political Science Review*, 104:1 (February 2010): 1-20.**
- Gordon, Sanford and Gregory Huber. 2007. The Effect of Electoral Competitiveness on Incumbent Behavior. *Quarterly Journal of Political Science* 2(2): 107-138.
- Eggers, Andrew and Jens Hainmueller. 2009. MPs for Sale? Estimating Returns to Office in Post-War British Politics. *American Political Science Review*. 103 (4): 513-533.
- Gilligan, Michael J. and Ernest J. Sergenti. 2008. Do UN Interventions Cause Peace? Using Matching to Improve Causal Inference. *Quarterly Journal of Political Science* 3 (2): 89-122.
- Sekhon, Jasjeet, and Rocło Titiunik. 2012. When Natural Experiments Are Neither Natural nor Experiments. *American Political Science Review* 106(1): 35-57.
- Rubin, Donald B. 2001. Using Propensity Scores to Help Design Observational Studies: Application to the Tobacco Litigation. *Health Services and Outcomes Research Methodology* 2 (3-4): 169-188.
- Blattman, Christopher. 2009. From Violence to Voting: War and Political Participation in Uganda. *American Political Science Review* 103 (2): 231-247.

### 3.3 Regression

OLS as an estimator of causal effects

*Readings:*

- **Angrist and Pischke: Chapter 3.**
- **Morgan and Winship: Chapters 6 and 7.**

- Härdle, W and Linton, O. 1994. Applied Nonparametric Methods, in R. F. Engle and D. L. McFadden eds. *Handbook of Econometrics*, vol. 4. New York: Elsevier Science.
- White, H. 1980. Using Least Squares to Approximate Unknown Regression Functions. *International Economic Review* 21: 149-170.

### 3.4 Partial Identification and Sensitivity Analysis

Nonparametric bounds, sensitivity analysis

*Readings:*

- **Morgan and Winship: Chapter 12**
- Guido W. Imbens. 2003. Sensitivity to Exogeneity Assumptions in Program Evaluation. *The American Economic Review* 93 (2): 126–32.
- Rosenbaum, Paul R. 2002. Observational Studies. Springer-Verlag. 2nd edition. Chapter 4.
- Manski, Charles F. 1995. *Identification Problems in the Social Sciences*. Cambridge: Harvard University Press. Chapter 2.
- Joseph Altonji, Todd E. Elder, and Christopher Taber. 2005. Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools. *Journal of Political Economy* Vol. 113: 151-184.
- VanderWeele, Tyler J. , and Onyebuchi A. Arah. 2011. Bias Formulas for Sensitivity Analysis of Unmeasured Confounding for General Outcomes, Treatments, and Confounders. *Epidemiology* 22 (1): 42.
- Rosenbaum, Paul R. 2009. Amplification of Sensitivity Analysis in Matched Observational Studies. *Journal of the American Statistical Association* 104 (488): 1398-1405.
- **Blattman, Christopher and Jeannie Annan. 2010. The Consequences of Child Soldiering. *Review of Economics and Statistics*, 42(4): 882–898.**
- Shadish, William R., M.H. Clark, and Peter M. Steiner. 2008. Can Nonrandomized Experiments Yield Accurate Answers? A Randomized Experiment Comparing Random and Nonrandom Assignments. *Journal of the American Statistical Association* 103 (484): 1334-1344.
- Dehejia, Rajeev H. 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.
- Heckman, James J., Hidehiko Ichimura and Petra Todd. 1998. Matching as an Econometric Evaluation Estimator, *Review of Economic Studies* 65: 261-294.
- Heckman, J., Ichimura, H., Smith, J., and Todd, P. 1998. Characterizing Selection Bias Using Experimental Data. *Econometrica*, 66(5), 1017-1098.
- Arceneaux, Kevin, Alan S. Gerber, and Donald P. Green. 2006. Comparing Experimental and Matching Methods using a Large-Scale Voter Mobilization Experiment. *Political Analysis* 14 (1): 1-36.

## 4 Instrumental Variables

Treatment noncompliance, principal stratification, local average treatment effects, Wald estimator and two-stage least squares

*Readings:*

- **Angrist and Pischke: Chapter 4**

- **Morgan and Winship: Chapter 9**
- 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.
- Balke, Alexander and Judea Pearl. 1997. Bounds on Treatment Effects from Studies with Imperfect Compliance. *Journal of the American Statistical Association*, 92: 1171–1176.
- Deaton, Angus. 2010. Instruments, Randomization, and Learning About Development. *Journal of Economic Literature* 48(2): 424-455.
- Hernan, Miguel A., and James M. Robins. 2006. Instruments for Causal Inference: An Epidemiologist's Dream? *Epidemiology* 17(4): 360-72.
- Imbens, Guido W. 2010. Better LATE Than Nothing: Some Comments on Deaton (2009) and Heckman and Urzua (2009). *Journal of Economic Literature* 48(2): 399-423.
- **Ananat, Elizabeth Oltmans, and Ebonya Washington. 2009. Segregation and Black Political Efficacy. Journal of Public Economics 93(5-6): 807-22.**
- Iyer, L. (2010). Direct versus Indirect Colonial Rule in India: Long-Term Consequences. *The Review of Economics and Statistics*, 92(4), 693-713.
- Angrist and Krueger. 2001 Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments
- Acemoglu, Daron, Simon Johnson, and James A. Robinson. 2001. The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review* 91(5): 1369-1401.
- Clingingsmith, David, Asim Ijaz Khwaja, and Michael Kremer. 2009. Estimating the Impact of the Hajj: Religion and Tolerance in Islam's Global Gathering. *Quarterly Journal of Economics* 124(3): 1133-1170.
- Hidalgo, F. Daniel, Suresh Naidu, Simeon Nichter, and Neal Richardson. 2010. Economic Determinants of Land Invasions. *Review of Economics and Statistics* 92(3): 505-523.
- Angrist, Joshua D. 1990. Lifetime Earnings and the Vietnam Era Draft Lottery: Evidence from Social Security Administrative Records. *American Economic Review* 80(3): 313-336.

## 5 Regression Discontinuity

Sharp and fuzzy designs, identification, estimation, falsification checks

*Readings:*

- **Angrist and Pischke: Chapter 6**
- **Skovron, Christopher and Roco Titiunik. 2015. A Practical Guide to Regression Discontinuity Designs in Political Science. *Working paper.***
- **de la Cuesta, Brandon and Kosuke Imai. 2016. Misunderstandings about the Regression Discontinuity Design in the Study of Close Elections. *Annual Review of Political Science* 19.**
- Imbens, Guido W., and Thomas Lemieux. 2008. Regression Discontinuity Designs: A Guide to Practice. *Journal of Econometrics* 142 (2): 615-35.
- Hahn, Jinyong, Petra Todd and Wilbert Van der Klaauw. 2001. Identification and Estimation of Treatment Effects with a Regression Discontinuity Design, *Econometrica* 69 (1): 201-209.
- Keele, Luke and Rocio Titiunik. 2015. Geographic Boundaries as Regression Discontinuities. *Political Analysis* 23 (1): 127-155.

- Lee, David S. 2008. Randomized Experiments from Non-random Selection in U.S. House Elections. *Journal of Econometrics* 142 (2): 675-697.
- Hidalgo, F. Daniel. 2010. Digital Democratization: Expanding the Electorate Through Voting Technology. *Working Paper*.
- Caughey, Devin, and Jasjeet Sekhon. 2011. Elections and the Regression Discontinuity Design: Lessons From Close U.S. House Races, 1942-2008. *Political Analysis* 19 (4): 385-408.
- Eggers, Andrew, Olle Folke, Anthony Fowler, Jens Hainmueller, Andrew Hall, and James Snyder. 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): 259-274.

## 6 Difference in Differences and Methods for Panel Data

Selection on time-invariant unobservables

*Readings:*

- **Angrist and Pischke: Chapter 5**
- Kim, In Song and Kosuke Imai. On the Use of Linear Fixed Effects Regression Estimators for Causal Inference. *Working Paper*.
- Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. 2004. How Much Should We Trust Differences-in-Differences Estimates? *Quarterly Journal of Economics* 119 (1): 249-275.
- **Acemoglu, Daron, Simon Johnson, James A. Robinson, and Pierre Yared. 2008. Income and Democracy. *American Economic Review* 98 (3): 808-842.**
- La Ferrara, Eliana, Albert Chong, and Suzanne Duryea. 2012. Soap Operas and Fertility: Evidence from Brazil. *American Economic Journal: Applied Econometrics* 4(4): 10-1.
- Ladd, Jonathan McDonald, and Gabriel S. Lenz. 2009. Exploiting a Rare Communication Shift to Document the Persuasive Power of the News Media. *American Journal of Political Science* 53 (2): 394-410.
- Berrebi, Claude. and Esteban F. Klor. 2008. Are Voters Sensitive to Terrorism? Direct Evidence from the Israeli Electorate. *American Political Science Review* 102 (3): 279-301.
- **Sances, Michael. 2015. The Distributional Impact of Greater Responsiveness: Evidence from New York Towns. *Journal of Politics* 78(1):105-119.**
- Lyall, Jason. 2009. Does Indiscriminate Violence Incite Insurgent Attacks? Evidence from Chechnya. *Journal of Conflict Resolution* 53 (3): 331-62.
- Card, David. and Alan B. Krueger. 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.
- **Abadie, A., A. Diamond, and J. Hainmueller. 2010. Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program. *Journal of the American Statistical Association*, 105: 493–505.**
- Bohn, S., M. Lofstrom and S. Raphael. 2014. Did the 2007 Legal Arizona Workers Act Reduce the State's Unauthorized Immigrant Population? *Review of Economics and Statistics* 96(2):258-269.
- Acemoglu, D., Simon, J., Kermani, A, Kwak, J. and T. Mitton. 2013. The Value of Connections In Turbulent Times: Evidence from the United States. NBER Working Paper.

# 7 Causal Mechanisms

Direct and indirect effects, sequential ignorability, sensitivity analysis and research designs

*Readings:*

- **Imai, K., L. Keele, D. Tingley and T. Yamamoto. 2011. Unpacking the Black Box of Causality: Learning about Causal Mechanisms from Experimental and Observational Studies.** *American Political Science Review*, **105(4), 765-789.**
- Imai, K., L. Keele and T. Yamamoto. 2010. Identification, Inference, and Sensitivity Analysis for Causal Mediation Effects. *Statistical Science*, 25(1), 51-71.
- Robins, James M. and Sander Greenland. 1992. Identifiability and Exchangeability of Direct and Indirect Effects. *Epidemiology*, 3: 143–155.
- Pearl, Judea. 2001. Direct and Indirect Effects. In *Proceedings of the Seventeenth Conference on Uncertainty in Artificial Intelligence*, 411–420.
- Imai, K., D. Tingley and T. Yamamoto. 2013. Experimental Designs for Identifying Causal Mechanisms. *Journal of the Royal Statistical Society, Series A*, 176(1), 5–51.