

# 90-906: Introduction to Econometric Theory

Professor Edson Severini  
Carnegie Mellon University  
Fall 2023, Heinz College  
MW, 2:00-3:20pm, HBH 2003

[edsons@andrew.cmu.edu](mailto:edsons@andrew.cmu.edu)

HBH 2212

412-268-2329

Teaching Assistant: André Cardoso ([acardoso@andrew.cmu.edu](mailto:acardoso@andrew.cmu.edu))

## Email Policy and Office Hours

Please email me only if my answer is expected to be a few words or sentences, and include “PhD Econometrics I - Fall 2023” on the subject. I will get back to you within 24 hours on weekdays, and 48 hours on weekends. That said, I prefer talking to you during my office hours, which will be held on Mondays, 4:50-5:50pm. The TA’s office hours will be posted on Canvas. You may also ask questions in the TA’s recitations, which you are required to attend.

## Course Description

Empirical research is most valuable when it uses data to answer specific causal questions, *as if* in a randomized clinical trial. In the absence of a real experiment, we look for well-controlled comparisons and/or natural quasi-experiments. Some research designs are more convincing than others, but the econometric methods behind them are almost always fairly simple. This course provides an introduction to the most important items in an applied econometrician’s toolkit: (i) analysis of randomized controlled trials; (ii) regression models designed to control for variables that may mask the causal effects of interest; (iii) difference-in-differences-type strategies that use repeated observations to control for unobserved omitted factors; and (iv) instrumental variables and regression discontinuity methods for the analysis of real and natural experiments. In this course, emphasis will be given to conceptual issues and statistical techniques that turn up in the applied research we read and do. Many empirical examples will illustrate these ideas and techniques.

## Prerequisite

90-905: Statistical Theory for Social and Policy Research (or equivalent; taken concomitantly)

The main prerequisite for this course is basic training in probability and statistics. Students should be comfortable with the elementary tools of statistical inference, such as standard errors and  $t$ -statistics. Familiarity with fundamental probability concepts such as mathematical expectation, and with principles of linear algebra such as vector and matrix operations, is also helpful, but extraordinary mathematical sophistication is not required.

## Course Objectives

Upon successful completion of this course, you should be able to:

1. Understand the key theoretical and practical elements of regression analysis.
2. Use the core methods in today’s econometric toolkit in empirical analysis – e.g., linear regression for statistical control, instrumental variable methods for the analysis of real and natural experiments, and difference-and-difference methods that exploit policy changes.

## Student Audience

Within the Heinz College, 90-906 is appropriate for first-year PhD students plus first and second year Masters students who desire and are prepared for a rigorous course in econometrics as a base for more advanced research methodology. Outside the Heinz school, 90-906 may be of interest to graduate students in Engineering and Public Policy, Social and Decision Science, Software Engineering, Psychology, GSIA, Philosophy, Applied History, or Architecture who need background in econometrics targeted toward social and policy research.

## Course Web Page

I plan to post slides, readings, homework, and announcements on Canvas: <http://www.cmu.edu/canvas/>

## Textbooks

The main textbooks for this course (and your professional life) are *Mostly Harmless Econometrics: An Empiricist's Companion*, by Joshua D. Angrist and Jörn-Steffen Pischke, and *Econometrics*, by Bruce E. Hansen (more information at <https://users.ssc.wisc.edu/~bhansen/econometrics/>). An old pre-print version of the Hansen's book is available on Canvas. These books cover the most important items in an applied econometrician's toolkit. Lectures will also draw from four additional references: *Econometric Analysis (7th Ed.)*, by William H. Greene, *Econometric Analysis of Cross Section and Panel Data (2nd Ed.)*, by Jeffrey M Wooldridge, *Causal Inference: The Mixtape*, by Scott Cunningham (available online at <https://mixtape.scunning.com>), and the chapter "Endogeneity in Empirical Corporate Finance", by Michael R. Roberts and Toni M. Whited, in the *Handbook of the Economics of Finance* Volume 2, 2012, edited by George Constantinides, Milton Harris, and Rene Stulz.

In case you are not familiar with the software to be used in the course – STATA –, you should acquire another book that provides detailed instructions on how to work with the software as well as the econometric theory behind the commands. The book is *Microeconometrics Using Stata (Revised Edition)*, by A. Colin Cameron and Pravin K. Trivedi. Another excellent option is the book *Causal Inference: The Mixtape* (see above), which contains examples of codes to implement each methodology in both softwares STATA, R, and Python. (If you would like use R or Python instead of STATA for your homework, you must learn the implementation of the methodologies on your own with the examples provided in *The Mixtape*, and submit detailed logfiles. The TA will not help with R or Python, and will not give you feedback on your use of these softwares.)

## Grading Scheme

Students are expected to attend and actively participate in class, complete assignments (readings, homework problems, paper replications, etc.), and take examinations. Students are also expected to attend recitations, and office hours as needed. There will be approximately bi-weekly assignments, including paper replications, and two exams. The final grade will be determined by a formula chosen by *each student* subject to the following constraints:

Grade Components	Range	Default
Class participation	5-10%	5%
Assignments	30-40%	35%
Exam 1	25-35%	30%
Exam 2	25-35%	30%
Total	100%	100%

The total of the percentages allocated by the student must total 100%. This allocation is intended to provide flexibility in the way a student demonstrates mastery of the course material. If no choice is made, grading will be by the default weights.

### **Regrade Policy**

If you feel that a regrade request is justified, please write down the reasons on a separate page, print it and staple it to the front of your exam/assignment, and bring it to me or the TA in class. If you like to use your old exams/assignments to study for the next exam, make a copy for yourself before handing them in. Deadline for regrades is *one week* after the return of the exams/assignments, unless a different date is announced in class. Late requests will not be considered.

If there was an arithmetic error in adding up points on your exam/assignment, let us know right away, and we will record the correct grade. This doesn't constitute a regrade request. Just write a brief note on the cover sheet and give the exam/assignment to me or the TA.

### **Cheating & Plagiarism**

Students are expected to honor the letter and the spirit of the Carnegie Mellon University Policy on Cheating and Plagiarism. All activities cited in that policy will be treated as cheating in this course. Students are expected to familiarize themselves with this policy. Students are also encouraged to review the Carnegie Mellon University Academic Disciplinary Actions Overview for Graduate Students, which details penalties and sanctions, as well as students' rights. I will take a zero-tolerance policy on cheating and plagiarism and will consult with Departmental leadership on appropriate action for all instances of cheating and plagiarism. As the aforementioned policies indicate, penalties can include course failure, suspension, and dismissal from the program.

-- *Carnegie Mellon University Policy on Cheating and Plagiarism*

<http://www.cmu.edu/policies/documents/Cheating.html>

-- *Carnegie Mellon University Academic Disciplinary Actions Overview for Graduate Students*

<http://www.cmu.edu/policies/documents/GradDisc.html>

### **Personal Accommodations**

Students with disabilities: If you wish to request an accommodation due to a documented disability, please inform me and contact Disability Resources as soon as possible. They can be reached at [access@andrew.cmu.edu](mailto:access@andrew.cmu.edu) or (412) 268-2013.

### **COVID-19 Protocol**

In order to attend class meetings in person, all students are expected to abide by all behaviors indicated in <https://www.cmu.edu/coronavirus/students/index.html>, including any timely updates based on the current conditions.

For this course, I will be recording class sessions and making them available to you for your personal, educational use. Recordings of class sessions are covered under the Family Educational Rights and Privacy Act (FERPA) and must not be shared with anyone outside your course-section. The purpose of these recording is so students in this course (and only students in this course) can watch or re-watch past class sessions. Feel free to use the recordings if you would like to review something we discussed in class or if you are temporarily unable to attend class.

## Thoughts for the Semester

Your graduate-school experience might prove to be mostly enjoyable and carefree, but it is likely to entail stress as well. The University Provost provides the following thoughts for students. They seem very sensible to us:

*Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.*

*All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.*

*If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services is here to help: call 412-268-2922 and visit their website at <http://www.cmu.edu/counseling/>. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.*

***We must treat every individual with respect.*** *We are diverse in many ways, and this diversity is fundamental to building and maintaining an equitable and inclusive campus community. Diversity can refer to multiple ways that we identify ourselves, including but not limited to race, color, national origin, language, sex, disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Each of these diverse identities, along with many others not mentioned here, shape the perspectives our students, faculty, and staff bring to our campus. We, at CMU, will work to promote diversity, equity and inclusion not only because diversity fuels excellence and innovation, but because we want to pursue justice. We acknowledge our imperfections while we also fully commit to the work, inside and outside of our classrooms, of building and sustaining a campus community that increasingly embraces these core values.*

*Each of us is responsible for creating a safer, more inclusive environment.*

*Unfortunately, incidents of bias or discrimination do occur, whether intentional or unintentional. They contribute to creating an unwelcoming environment for individuals and groups at the university. Therefore, the university encourages anyone who experiences or observes unfair or hostile treatment on the basis of identity to speak out for justice and support, within the moment of the incident or after the incident has passed. Anyone can share these experiences using the following resources:*

**Center for Student Diversity and Inclusion:** [csdi@andrew.cmu.edu](mailto:csdi@andrew.cmu.edu), (412) 268-2150

**Report it online (anonymous reporting platform):** <http://reportit.net> username: tartans password: plaid

*All reports will be documented and deliberated to determine if there should be any following actions. Regardless of incident type, the university will use all shared experiences to transform our campus climate to be more equitable and just.*

## TOPICS TO BE COVERED IN THE COURSE

### 1. Regression Analysis – Cross Section and Panel Data (5 weeks)

#### Examples:

- 1) Ashenfelter, Orley. (2008). "Predicting the quality and prices of Bordeaux wine." *Economic Journal* 118(529): F174-F184.
- 2) Dale, Stacy Berg, and Alan B. Krueger. (2002). "Estimating the Payoff to Attending a More Selective College: An Application of Selection on Observables and Unobservables." *Quarterly Journal of Economics* 117(4): 1491-1527.
- 3) Fryer, Roland G. Jr., and Steven D. Levitt. (2013). "Testing for Racial Differences in the Mental Ability of Young Children." *American Economic Review* 103(2): 981-1005.
- 4) Neal, Derek A., and William R. Johnson. (1996). "The Role of Premarket Factors in Black-White Wage Differences." *Journal of Political Economy* 104(5): 869-895.

*Replication in Recitation:* Deschênes, Olivier, and Michael Greenstone. (2011). "Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the US." *American Economic Journal: Applied Economics*, 3(4): 152-85.

#### Optional additional readings:

Deschenes, Olivier, and Michael Greenstone. (2007). "The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather." *American Economic Review* 97(1): 354-385. [Deschenes, Olivier, and Michael Greenstone. (2012). "The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather: Reply." *American Economic Review* 102(7): 3761-73.]

Fisher, Anthony C., W. Michael Hanemann, Michael J. Roberts, and Wolfram Schlenker. (2012). "The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather: Comment." *American Economic Review* 102(7): 3749-60.

Mendelsohn, Robert, William D. Nordhaus, and Daigee Shaw. (1994). "The Impact of Global Warming on Agriculture: A Ricardian Analysis." *American Economic Review* 84(4): 753-771.

### 2. Instrumental Variables (2 weeks)

#### Examples:

- 1) Angrist, Joshua D., Victor Lavy, and Analia Schlosser. (2010). "Multiple experiments for the causal link between the quantity and quality of children," *Journal of Labor Economics* 28(4): 773-824.
- 2) Bennedsen, Morten, Kasper Meisner Nielsen, Francisco Perez-Gonzalez, and Daniel Wolfenzon. (2007). "Inside the Family Firm: The Role of Families in Succession Decisions and Performance." *Quarterly Journal of Economics* 122(2): 647-691.
- 3) Duranton, Gilles, and Matthew A. Turner. (2011). "The Fundamental Law of Road Congestion: Evidence from US Cities." *American Economic Review*, 101(6): 2616-52.

4) Black, Dan A., Seth G. Sanders, Evan J. Taylor, and Lowell J. Taylor. (2015). "The Impact of the Great Migration on Mortality of African Americans: Evidence from the Deep South." *American Economic Review*, 105(2): 477-503.

*Replication in Recitation*: Goldsmith-Pinkham, Paul, Isaac Sorkin, and Henry Swift. (2020). "Bartik Instruments: What, When, Why, and How." *American Economic Review*, 110(8): 2586-2624.

*Replication as Homework*: Duranton, Gilles, and Matthew A. Turner. (2011). "The Fundamental Law of Road Congestion: Evidence from US Cities." *American Economic Review*, 101(6): 2616-52.

Optional additional reading:

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

### **3. Randomized Controlled Trial (1 week)**

*Examples*:

1) Bertrand, Marianne, and Sendhil Mullainathan. (2004). "Are Emily and Greg More Employable Than Lakisha and Jamal? A Field Experiment on Labor Market Discrimination." *American Economic Review*, 94(4): 991-1013.

2) Ferraro, Paul J., Juan Jose Miranda, and Michael K. Price. (2011). "The Persistence of Treatment Effects with Norm-Based Policy Instruments: Evidence from a Randomized Environmental Policy Experiment." *American Economic Review*, 101(3): 318-22.

3) Krueger, Alan B. (1999). "Experimental Estimates of Education Production Functions." *Quarterly Journal of Economics* 114(2): 497-532.

*Replication in Recitation*: Royer, Heather, Mark Stehr, and Justin Sydnor. (2015). "Incentives, Commitments, and Habit Formation in Exercise: Evidence from a Field Experiment with Workers at a Fortune-500 Company." *American Economic Journal: Applied Economics*, 7(3): 51-84.

*Replication as Homework*: Pons, Vincent. (2018). "Will a Five-Minute Discussion Change Your Mind? A Countrywide Experiment on Voter Choice in France." *American Economic Review*, 108(6): 1322-63.

Optional additional readings:

Aron-Dine, Aviva, Liran Einav and Amy Finkelstein. (2013). "The RAND Health Insurance Experiment, Three Decades Later." *Journal of Economic Perspectives* 27(1): 197-222.

Baicker, Katherine, Sarah L. Taubman, Heidi L. Allen, Mira Bernstein, Jonathan H. Gruber, Joseph P. Newhouse, Eric C. Schneider, Bill J. Wright, Alan M. Zaslavsky, and Amy N. Finkelstein, for the Oregon Health Study Group. (2013). "The Oregon Experiment – Effects of Medicaid on Clinical Outcomes." *New England Journal of Medicine* 368(18): 1713-1722.

Finkelstein, Amy, Sarah Taubman, Bill Wright, Mira Bernstein, Jonathan Gruber, Joseph P. Newhouse, Heidi Allen, Katherine Baicker, and the Oregon Health Study Group. (2012). "The Oregon Health Insurance Experiment: Evidence from the First Year." *Quarterly Journal of Economics* 127(3): 1057-1106.

Taubman, Sarah L., Heidi L. Allen, Bill J. Wright, Katherine Baicker, and Amy N. Finkelstein. (2014). "Medicaid Increases Emergency-Department Use: Evidence from Oregon's Health Insurance Experiment." *Science* 343(6168): 263-268.

Woodbury, Stephen A., and Robert G. Spiegelman. (1987). "Bonuses to workers and employers to reduce unemployment: Randomized trials in Illinois." *American Economic Review* 77(4): 513-530.

#### 4. Difference in Differences (3 weeks)

##### *Examples:*

- 1) Autor, David H. (2003). "Outsourcing at Will: The Contribution of Unjust Dismissal Doctrine to the Growth of Employment Outsourcing." *Journal of Labor Economics* 21(1): 1-42.
- 2) 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): 772-93.  
[Card, David, and Alan B. Krueger. (2000). "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania: Reply." *American Economic Review* 90(5): 1397-1420.]
- 3) Currie, Janet, Lucas Davis, Michael Greenstone, and Reed Walker. (2015). "Environmental Health Risks and Housing Values: Evidence from 1,600 Toxic Plant Openings and Closings." *American Economic Review*, 105(2): 678-709.
- 4) Davis, Lucas W. (2004). "The Effect of Health Risk on Housing Values: Evidence from a Cancer Cluster." *American Economic Review*, 94(5): 1693-1704.
- 5) Kline, Patrick. (2012). "The Impact of Juvenile Curfew Laws on Arrests of Youth and Adults." *American Law and Economics Review*, 14(1): 44-67.
- 6) McCrary, Justin. (2007). "The Effect of Court-Ordered Hiring Quotas on the Composition and Quality of Police." *American Economic Review* 97(1): 318-353.

*Replication in Recitation:* Davis, Lucas W. (2004). "The Effect of Health Risk on Housing Values: Evidence from a Cancer Cluster." *American Economic Review*, 94(5): 1693-1704.

*Replication as Homework:* Baker, Andrew C., David F. Larcker, Charles C.Y. Wang. (2022). "How Much Should We Trust Staggered Difference-in-Differences Estimates?" *Journal of Financial Economics* 144(2): 370-395. (Read the entire paper, but replicate only subsection 5.1 – R codes are available at [https://github.com/andrewcbaker/JFE\\_DID](https://github.com/andrewcbaker/JFE_DID).)

##### Optional additional readings:

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.

Eissa, Nada, and Jeffrey B. Liebman. (1996). "Labor Supply Response to the Earned Income Tax Credit." *Quarterly Journal of Economics* 111(2): 605-637.

Jalil, Andrew J. (2014). "Monetary Intervention Really Did Mitigate Banking Panics During the Great Depression: Evidence Along the Atlanta Federal Reserve District Border." *Journal of Economic History* 74(1): 259-273.

Linden, Leigh, and Jonah E. Rockoff. (2008). "Estimates of the Impact of Crime Risk on Property Values from Megan's Laws." *American Economic Review*, 98(3): 1103-27.

Richardson, Gary, and William Troost. (2009). "Monetary Intervention Mitigated Banking Panics during the Great Depression: Quasi-Experimental Evidence from a Federal Reserve District Border, 1929–1933." *Journal of Political Economy*, 117(6): 1031-1073.

Roth, Jonathan, Pedro H.C. Sant'Anna, Alyssa Bilinski, and John Poe. (2023). "What's trending in difference-in-differences? A synthesis of the recent econometrics literature." *Journal of Econometrics* 235(2): 2218-2244.

## 5. Regression Discontinuity Design (3 weeks)

### Examples:

1) Anderson, Michael L. (2014). "Subways, Strikes, and Slowdowns: The Impacts of Public Transit on Traffic Congestion." *American Economic Review*, 104(9): 2763-96.

2) Clark, Damon and Heather Royer. (2013). "The Effect of Education on Adult Mortality and Health: Evidence from Britain." *American Economic Review*, 103(6): 2087-2120.

3) Howell, Sabrina T. (2017). "Financing Innovation: Evidence from R&D Grants." *American Economic Review*, 107(4): 1136-64.

4) Nekoei, Arash, and Andrea Weber. (2017). "Does Extending Unemployment Benefits Improve Job Quality?" *American Economic Review*, 107(2): 527-61.

*Replication in Recitation:* Solis, Alex. (2017). "Credit Access and College Enrollment." *Journal of Political Economy*, 125(2): 562-622.

*Replication as Homework:* Anderson, Michael L. (2014). "Subways, Strikes, and Slowdowns: The Impacts of Public Transit on Traffic Congestion." *American Economic Review*, 104(9): 2763-96.

### Optional additional readings:

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

Carpenter, Christopher, and Carlos Dobkin. (2009). "The Effect of Alcohol Consumption on Mortality: Regression Discontinuity Evidence from the Minimum Drinking Age." *American Economic Journal: Applied Economics*, 1(1): 164-82.



McCrary, Justin. (2008). "Manipulation of the Running Variable in the Regression Discontinuity Design: A Density Test." *Journal of Econometrics*, 142(2): 698-714.

Urquiola, Miguel, and Eric Verhoogen. (2009). "Class-Size Caps, Sorting, and the Regression-Discontinuity Design." *American Economic Review*, 99(1): 179-215.