University of Nevada, Reno
ECON 441: Introduction to Econometrics[†]
Fall 2024 (8/26 - 12/18)

Professor:	Pierce Donovan	pierce.donovan@unr.edu
Lectures:	(1) AB 213	TR 10:30 am - 11:45 am
	(2) AB 213	TR 1:30 pm - 2:45 pm
Office Hours:	AB 318F	TRF 9:00 am - 10:00 am

Course Description and Objectives

Statistics provides us with a set of tools that enables us to make sense of uncertainty—which is generally something humans try to avoid. Alas, data in situ emit an inherently *noisy* signal, and we must embrace this fact if we are to conduct empirical research. But if we understand how to collect, analyze, and draw conclusions from data, we can begin to recover some knowledge, or, more precisely, recognize patterns that may not be due to chance.

Econometrics builds on statistics by taking the interpretation and presentation of statistical output particularly seriously. Good econometric work is different from other data sciences because it involves *clear, causal thinking*. Many questions worth asking will require something more careful and creative than mere calculation. Do smaller class sizes promote better student performance? Can city air quality be improved by implementing driving restrictions? How does increased police presence affect crime rates? During this course you will begin to understand how to answer questions like these in a convincing manner.

You have two tasks in this course: (1) learn how to assess the strengths and weaknesses of different empirical approaches and intuit the "feel" of good causal inference, and (2) learn what empirical work in economics looks like and become more comfortable with using data to tell a story. To understand proper *research design*, we'll explore common methods in modern econometrics through example. The course focuses on regression analysis, a tool that allows us to control for confounding factors embedded in real-world data and isolate causal effects. I aim to provide an exciting take on an interesting field while supplying you with the tools to become successful econometricians.

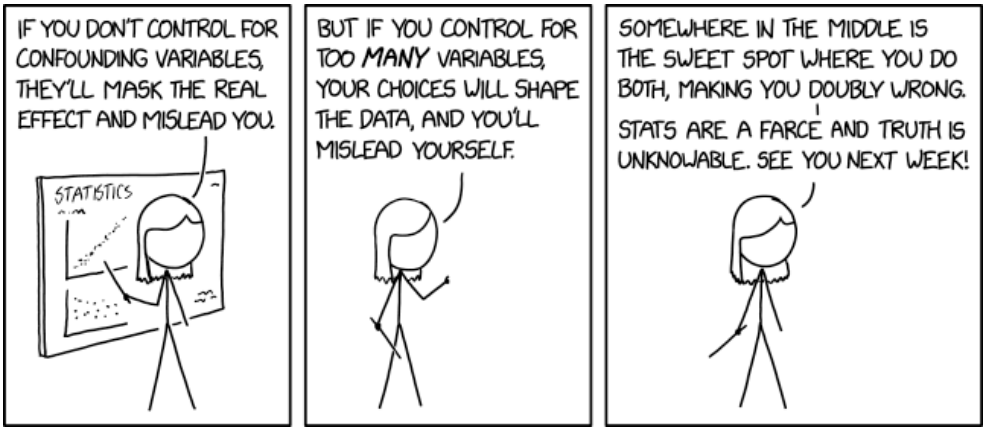

Figure 1: *Confounding Variables*, XKCD (12/27/2021).

[†]As the semester goes on, I may change the contents of this syllabus regarding the schedule, grading, or other details.

Prerequisites and Expectations

The prerequisite courses are Principles of Micro/Macro (ECON 102/103) and Principles of Statistics II (ECON 262). Success in this course will in no small part be due to your previous mastery of the concepts learned there. It helps to be familiar with concepts from calculus, but this is not essential.

Another prerequisite is a healthy learning attitude. Don't expect to fully-understand the material upon your first [passive] exposure during lecture. ECON 441 is one of those classes that takes a lot of effort outside of the classroom. Learning is supposed to take time, and it is supposed to be uncomfortable! Struggling with a concept is a precursor to truly understanding something. If you acknowledge that this will happen from time to time, there's suddenly no reason to feel frustrated, and that makes it easier to enjoy the process of figuring something out. I hope to show you that *'Metrics* is both a challenging and incredibly fun subject to explore during your time at UNR.

You should aim to become more independent over the course of the semester. For example, before coming to me, reflect on what you have tried and write down what didn't work and *why you think it didn't work*. You'll either spot the issue yourself, or come to me with your problem clearly identified. This strategy will keep you from giving up at the first sign of struggle, and is particularly-helpful when learning how to code in `STATA`—the programming language used in this course.[†]

You're responsible for wanting to become (and becoming!) a competent econometrician. I can't accomplish this for you. Consider my role in the class. I am like your personal trainer: I provide you with your workout regimen (the lecture content, assignments, readings, and direction), and you choose how you want to follow that plan. If you play an active role in class, regularly review your notes outside of class, and keep up with office hours, you're setting yourself up for success.

Teaching Assistant

Aastha Pudasainee (apudasainee@unr.edu) is our course TA. She is responsible for grading your assignments and helping you with your `STATA` code. You can ask her about the rest of the course material as well, although to protect her time (she's also a student!), please ask me theory/lecture-based questions first. Her office hours will be 11:00 am - 12:00 pm MW in Ansari 520.

Textbook

Most of our instruction is inspired by *Mastering Metrics: The Path From Cause to Effect*, by Joshua D. Angrist and Jörn-Steffen Pischke (2014). The book is required for the course. You will be expected to have read the appropriate sections *before* the relevant lectures. The best way to follow along in the class is to have read the readings in advance. From time to time I may also assign other readings for certain lectures or homework assignments. For the reading schedule, see the course outline.

[†]Independence becomes invaluable when debugging `STATA` problems because your bugs have been squashed many times before (and answered online in great detail). You'll soon discover for yourself which resources you learn best from. `Google` is obviously useful here. As are the official `STATA` guides. `Wikipedia` is a great starting point for reviewing certain theoretical concepts. `StackExchange` provides invaluable discussion on some of the harder ideas. `Youtube` has hundreds of lessons and tutorials that could augment my lectures. Your classmates are also a great resource.

Homework (40% of grade)

There is typically one assignment due each week (12 in total). They are always due at 10:00 AM on Tuesday.[†] I recommend working on these assignments in groups of two, although you may also submit on your own. You may work with a student in another section of the course. The homework will alternate between analytical exercises and empirical assignments—the former follow the theory from my lectures and the latter force you to build complementary skills in `STATA`. The `STATA` assignments have an in-class lab component (AB 312) to help you get started. Late assignments will be accepted for two additional days with a fifteen percentage-point penalty per day.

Each submission must be uploaded to `Gradescope` as a single PDF file. You must also mark the relevant pages for each question listed in the rubric and add your partner (if you choose to have one) to your submissions yourself. I expect clean and professional-looking submissions. Assignments that require `STATA` should contain *curated* regression output and neat tables/figures (i.e. not gobs of copy-and-pasted lines from the `STATA` output log), with your full code attached as an appendix. This code should be well-documented (headings, ownership, comments, etc.) so that anyone with some `STATA` experience could read and understand what it does (you should want to do this anyway because you can usually reuse code from one week to the next).

Exams (60% of grade)

I design exams to evaluate how well you keep up with the assigned material and re-emphasize important points. They are opportunities for feedback and additional learning. I hope to make you think critically about problems that you haven't faced before. That being said, you will find that the [three] exams are highly correlated in content and style with the lecture notes and homework. The course is naturally cumulative, but each exam covers around a third of the material. Late exams will not be considered. Extenuating circumstances may invoke a change in grading scheme.

Grading

I don't give grades; you earn them by showcasing your understanding of the material. Further, I don't judge your performance relative to your peers (i.e. curve your grades) during the semester in order for you to have the clearest signal about your performance. Upon completion of the course, I will assign letter grades according to natural breaks in the grade distribution. This clustering method is occasionally more-generous than the typical binning schemes you may be used to.

Letters of Recommendation

If you earn an A in one of my courses and are an active participant in class or office hours, I am happy to write you a letter of recommendation. Please make your request well-before the application deadline so I can write something of use to your case. If you think I would be able to write a strong letter, please email me with (1) your resume, (2) a description/link to what you're applying for, (3) potential directions for the letter, and (4) where/to whom to send, and we can set up a meeting.

[†]Your effort on these assignments does not have to be constrained to Mondays. Please work ahead of schedule.

Course Conduct

- Missing lecture isn't the end of the world. If you feel sick, please stay home, take the time to recover, and get notes from a friend. I don't need an excuse, but be in touch if you will be out for multiple days. Chronic *undocumented* absences may result in course failure.
- Come to office hours! They're there for you! Asking clarifying questions about my material or assignments and talking with me about your interests beyond my courses are both good habits to start and can greatly improve your college experience (or a recommendation letter).
- When asking for help outside of class, the best students show me how they have approached a problem and their progress up to that point. Simply asking for an answer is not a productive use of our time. I hope to facilitate critical thinking, and that takes effort on everyone's part.
- While I'll be accessible by email, I strongly prefer communicating during class/office hours. Regarding boundaries, I do not plan on answering emails late at night or on the weekend.
- I will not tolerate academic dishonesty. You can review University of Nevada, Reno's Honor Code [`here`]. I will report any suspected cheating, plagiarism, manipulation, or other misconduct.
- You do not have permission to make any form of recording during class or office hours. You also do not have permission to share or publish my course materials (lecture notes, homework answers, exams)—or any derived content like your responses to homework and tests.
- You are responsible for your technology problems. Submit assignments well ahead of the due date if you want to be sure that your submission is received/in the proper format/etc.
- Please be respectful to your classmates. Refrain from talking during class if it is not relevant to lecture or discussion. Cell phone or tablet use should not detract from your ability to follow along with class. No activity on your part should undermine the efforts of other students.
- In my contribution towards an inclusive and intellectually-vibrant community, I aim to reflect the ideals presented in the Principles of Good Practice for Student Affairs (`link`) in my capacity as a professor at University of Nevada, Reno. I hope you will too.

Highlighted Student Resources

- I can't recommend our University Tutoring Services (`link`) enough. And the Writing and Speaking Center (`link`) is available to help you work on clear and coherent communication. Focused writing takes practice, and college is a great time to put in the hours. The same goes for math! The University Math Center (`link`) provides drop-in tutoring for math help.
- If you have a learning disability or a physical disability that requires accommodation, please let me know as soon as possible. For more information, or to arrange accommodations, contact the Disability Resource Center (`link`).
- If you have any issues within or outside this course that are affecting your work, and you lack someone to talk to, I will do my best to help. Keep in mind that I am a mandatory reporter under Title IX and may need to report what you share with me. In cases where I'm not the appropriate resource, please seek support from Downing Counseling Clinic (`link`).
- The University of Nevada, Reno is committed to providing a safe learning and work environment for all. If you believe you have experienced discrimination, sexual harassment, sexual assault, domestic/dating violence, or stalking, whether on or off campus, or need information related to immigration concerns, please contact the University's Equal Opportunity & Title IX office (`link`).

Course Outline

Transitioning from Statistical to Causal Inference

Background Probability and [Frequentist] Statistics ..... Tuesday, 8/27

Mastering 'Metrics: Intro

Concepts: random variable, sampling, data-generating process, probability distribution, parameter, p-values, confidence intervals, inference

More on Statistical Inference ..... Thursday, 8/29

Concepts: sampling variance, estimators, law of large numbers, consistency, unbiasedness, the central limit theorem, t-statistics, hypothesis testing and statistical significance

Lab Session 1: Introduction to STATA ..... Tuesday, 9/3

Homework #1 due.

Expectation and Variance Operators ..... Thursday, 9/5

Concepts: data reduction, summation operator, properties of expectation/variance/covariance

The Potential Outcomes Framework ..... Tuesday, 9/10

Mastering 'Metrics: Chapter 1, Chapter 1 Appendix

Reading: NYT analysis of the Nike Vaporfly (link: NYT)

Concepts: treatment and control groups, dummy variables, counterfactuals, selection bias

Homework #2 (STATA assignment) due.

Randomized Controlled Trials ..... Thursday, 9/12

Mastering 'Metrics: Chapter 1, Chapter 1 Appendix

Concepts: random assignment, conditional expectation, average treatment effects

Lab Session 2: Randomized Controlled Trials ..... Tuesday, 9/17

Homework #3 due.

Linear Regression and Causal Inference

Regression Anatomy ..... Thursday, 9/19

Mastering 'Metrics: Chapter 2 Appendix

Concepts: curve-fitting, residuals, optimization, the least-squares estimator

Regression Physiology ..... Tuesday, 9/24

Mastering 'Metrics: Chapter 2 Appendix

Concepts: Gauss-Markov assumptions, distribution of regression parameters

Homework #4 (STATA assignment) due.

Exam 1 Review Session ..... Thursday, 9/26

Exam 1: Statistical Inference and Randomization ..... Tuesday, 10/1

Regression as a Matchmaker ..... Thursday, 10/3

Mastering 'Metrics: Chapter 2
Concepts: selection on observables, omitted variables bias, causal vs control variables

Lab Session 3: Linear Regression in Practice ..... Tuesday, 10/8

Homework #5 due.

Directed Acyclic Graphs ..... Thursday, 10/10

Reading: Donovan (2024), *Visualizing Environmental Econometrics*
Concepts: confounder and collider variables, front/back-door paths, conditions for causality

Visualizing a Data-Generating Process ..... Tuesday, 10/15

Concepts: bias, bad controls, "conditioning on/controlling for" vs "holding things constant"
Homework #6 (STATA assignment) due.

Identifying Variation and Model Specification ..... Thursday, 10/17

Mastering 'Metrics: Chapter 2, Chapter 2 Appendix
Concepts: identifying variation, panel data, fixed-effects, log models and percent changes, interaction variables and heterogeneous effects, polynomials and non-constant effects

Exam 2 Review Session ..... Tuesday, 10/22

Homework #7 due.

Exam 2: Causal Inference ..... Thursday, 10/24

Research Design

Instrumental Variables ..... Tuesday, 10/29

Mastering 'Metrics: Chapter 3
Concepts: "partialing out" procedure, instrument, proxy variable, two-stage least squares, exclusion and independence of an instrument

IV and Validity ..... Thursday, 10/31

Mastering 'Metrics: Chapter 3
Concepts: intent-to-treat effect, local average treatment effect, internal and external validity

Regression Discontinuity: Design ..... Tuesday, 11/5

Mastering 'Metrics: Chapter 4
Concepts: running variable, threshold, jump, "local randomization," natural experiments
Homework #8 due.

R_2D Two: Electric Boogaloo ..... Thursday, 11/7

Mastering 'Metrics: Chapter 4
Concepts: bandwidth, local linear regression, polynomials and splines

Fuzzy Regression Discontinuity ..... Tuesday, 11/12

Mastering 'Metrics: Chapter 4
Concepts: "ocular" econometrics, imperfect treatment, instrumental variables again
Homework #9 due.

Lab Session 4: Fuzzy Regression Discontinuity ..... Thursday, 11/14

Differences-in-Differences: Design ..... Tuesday, 11/19

Mastering 'Metrics: Chapter 5
Concepts: panel data, common (parallel) trends, time trends, interaction variables
Homework #10 (STATA assignment) due.

Deeper into "Diff-in-Diff" ..... Thursday, 11/21

Mastering 'Metrics: Chapter 5
Concepts: placebo variables, serial correlation, clustered errors

Lab Session 5: Differences-in-Differences ..... Tuesday, 11/26

Homework #11 due.

No class (Thanksgiving Break) ..... Thursday, 11/28

No class (Extended Break) ..... Tuesday, 12/3

Homework #12 (STATA assignment) due.

Exam 3 Review Session ..... Thursday, 12/5

Exam 3: Research Design ..... Tuesday, 12/10