

Connecticut College
ECO 356: Advanced Econometrics[†]
Fall 2022 (8/30 - 12/19)

Professor:	Pierce Donovan	pdonovan@conncoll.edu
Lectures:	Fanning 417B	MW 10:25 - 11:40 am
Office Hours:	Winthrop 305	MW 12:00 - 1:00 pm F 10:00 am - 12:00pm

Course Description and Objectives

Statistics provides us with a set of tools to understand variation and uncertainty, which are generally things humans try to avoid. But if we learn about some of the ways to collect, analyze, and draw conclusions from data—which on their own emit an inherently *noisy* signal—we can begin to recover some knowledge, or, more precisely, recognize patterns that may not be due to chance.

Econometrics builds on this by taking the interpretation and presentation of statistical analyses particularly seriously. Good econometric work is different from other data sciences because it involves *clear, causal thinking*. When it comes to understanding the relationships between different variables, many questions worth asking require careful and creative analysis. 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.

In this course, your task is twofold: (1) learn how to assess the strengths and weaknesses of different empirical approaches and intuit the “feel” of good causal inference, and (2) learn how to conduct empirical work in economics 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.

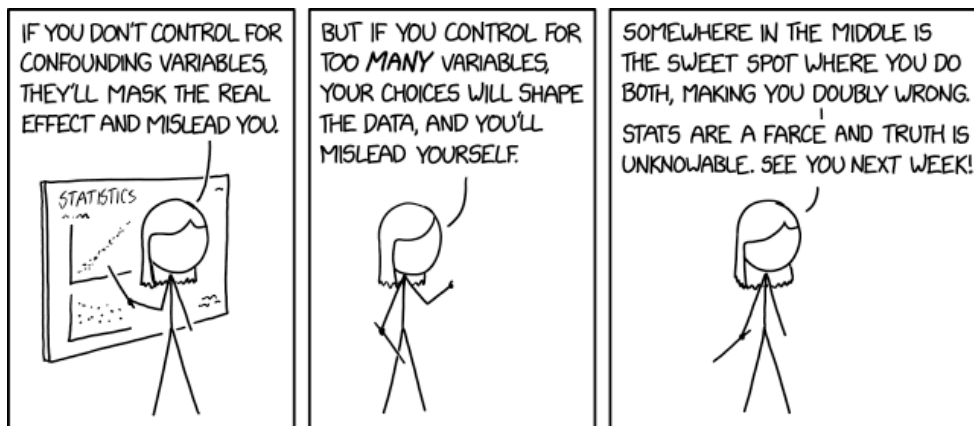


Figure 1: *Confounding Variables*, XKCD (12/27/2021).

[†]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 Econometrics I (ECO 230) and Calculus B (MAT 112). Success in this course will in no small part be due to your previous mastery of the concepts learned there.

Another prerequisite is a healthy learning attitude. Don't expect to fully-understand the material upon your first [passive] exposure during lecture. ECO 356 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 Conn.

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.

You will be building on your ECO 230-level ability to conduct empirical analyses in STATA. With respect to coding, independence becomes invaluable when debugging STATA problems because your bugs have been squashed many times before (and answered online in great detail). If you put in the effort into learning how to describe your coding problems, it'll become much easier to find those solutions.[†]

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—which you'll find on Moodle), 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.

Textbook(s)

Most of our instruction will be inspired by the following book:

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.

[†]You'll soon discover for yourself which resources you learn best from. Google is very 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. On top of all of this, your classmates are also a great coding resource.

Homework, Labs, and the Term Paper

There will be seven homework assignments and six labs due before class on select Wednesdays throughout the semester.[†] I recommend working on these assignments in groups of two or three. The homework assignments will tackle theoretical and analytical questions while the labs will complement the theory from my lectures and improve your empirical skills in STATA.^{††} You may find it useful to complete each homework before its corresponding lab. Late assignments will be accepted for two additional days with a ten percentage-point penalty per day.

Each submission will be uploaded to Gradescope as a single PDF file. You must mark the relevant pages for each question listed in the rubric and add partners to your submissions yourselves. For your lab reports, I want to see a clean and professional-looking walkthrough answering each question, using *curated* regression output and neat tables/figures (i.e. not gobs of copy-and-pasted lines from the STATA output log). I shouldn't struggle to understand your analysis or code. As an appendix, you should print your STATA code as a PDF and attach it to the PDF of your lab report before uploading. 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).

Your *term paper* is another sort of lab report, although a more self-directed one—as it is on a topic of your [and a partner's] choosing and is somewhat open-ended. You will gain a better understanding of empirical economic research in practice and pick up some additional techniques beyond what we cover during lecture. We will build up to your final product together throughout the semester. For more on the paper, check out the *term paper timeline* document on the course Moodle page.

Exams

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 class notes and labs/homework. The course is naturally cumulative, but each exam covers around a third of the material.

Grading

I don't give grades, you earn them. Further, I don't judge your performance relative to your peers (i.e. curve your grades) during the term in order for you to have the clearest signal about your performance. I look for a proven understanding of the material via the following:

Assignments and Exams (84%)		Term Paper (16%)	
21%	Homework (3% each, x7)	3%	Topic Proposal
18%	Labs (3% each, x6)	3%	Status Update
45%	Exams (15% each, x3)	10%	Paper Submission

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

^{††}I will not be spending time on STATA during class—it will be up to you to learn how to use this statistical software via your lab work (and office hours). Because you have previous experience with STATA already from ECO 230, I believe my “walkthrough-style” labs will be fairly straightforward.

Not Boilerplate (please take a moment to read)

- Missing lecture isn't the end of the world. For example, if you feel sick, please don't come to class, 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.
- There are lots of things to learn in college besides my material, and there are lots of ways to optimize your learning experience. The Academic Resource Center ([link](#)) can assist you in getting the most out of your time and effort at Connecticut College.
- I can't recommend the tutoring services at the Roth Writing Center ([link](#)) enough if you want to work on clear and coherent communication. Focused writing takes practice, and college is a great time to put in the hours.
- If you have a learning disability or a physical disability that requires accommodation, please let me know as soon as possible. For more information on accommodation, you can contact Student Accessibility Services ([link](#)).
- I will not tolerate academic dishonesty. You can review Connecticut College'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 (with the exception of those granted accommodations through Student Accessibility Services). 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.
- 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 will need to report information regarding gender-based discrimination or sexual misconduct if you choose to share it with me. In cases where I'm not the appropriate resource, please seek support from Student Counseling Services ([link](#)).
- In my contribution towards an inclusive and intellectually-vibrant community, I aim to reflect the ideals presented in our school statements on Freedom of Expression ([link](#)) and Principles of Community ([link](#)) in my capacity as a professor at Connecticut College. I hope you do too.

Course Outline

Transitioning from Statistical to Causal Inference

Background Probability and [Frequentist] Statistics Wednesday, 8/31

Mastering 'Metrics: Intro

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

More on Statistical Inference Monday, 9/5

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

Expectation and Variance Operators Wednesday, 9/7

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

Homework #1 due.

The Potential Outcomes Framework Monday, 9/12

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

Randomized Controlled Trials Wednesday, 9/14

Mastering 'Metrics: Chapter 1, Chapter 1 Appendix

Concepts: random assignment, conditional expectation, average treatment effects

Lab #1 due.

Linear Regression and Causal Inference

Regression Anatomy Monday, 9/19

Mastering 'Metrics: Chapter 2 Appendix

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

Regression Physiology Wednesday, 9/21

Mastering 'Metrics: Chapter 2 Appendix

Concepts: Gauss-Markov assumptions, distribution of regression parameters

Homework #2 due.

Regression as a Matchmaker Monday, 9/26

Mastering 'Metrics: Chapter 2

Concepts: selection on observables, omitted variables bias, causal vs control variables

Linear Regression and Causal Inference, cont'd.

Directed Acyclic Graphs Wednesday, 9/28

Causal Inference Mixtape: Directed Acyclic Graphs

Concepts: confounder and collider variables, front/back-door paths, conditions for causality

Lab #2 due.

Visualizing a Data-Generating Process Monday, 10/3

Concepts: bias, bad controls, "conditioning on/controlling for" vs "holding things constant"

No class (Yom Kippur) Wednesday, 10/5

Homework #3 due.

Lab #3 due.

Exam 1 Review Session Monday, 10/10

Exam 1: Statistical Inference and Randomization Wednesday, 10/12

No class (Fall Break) Monday, 10/17

Identifying Variation and Model Specification Wednesday, 10/19

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

Term paper proposal due.

Exam 2 Review Session Monday, 10/24

Exam 2: Causal Inference Wednesday, 10/26

Homework #4 due.

Research Design

Instrumental Variables Monday, 10/31

Mastering 'Metrics: Chapter 3

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

IV and Validity Wednesday, 11/2

Mastering 'Metrics: Chapter 3

Concepts: intent-to-treat effect, local average treatment effect, internal and external validity

Lab #4 due.

Research Design, cont'd.

Regression Discontinuity: Design Monday, 11/7

Mastering 'Metrics: Chapter 4

Concepts: running variable, threshold, jump, "local randomization," natural experiments

R₂D Two: Electric Boogaloo Wednesday, 11/9

Mastering 'Metrics: Chapter 4

Concepts: bandwidth, local linear regression, polynomials and splines

Homework #5 due.

(There is no Lab #5. I just wanted the lab/homework numbers to match.)

Fuzzy Regression Discontinuity Monday, 11/14

Mastering 'Metrics: Chapter 4

Concepts: "ocular" econometrics, imperfect treatment, instrumental variables again

Differences-in-Differences: Design Wednesday, 11/16

Mastering 'Metrics: Chapter 5

Concepts: panel data, common (parallel) trends, time trends, interaction variables

Term paper status update due.

Deeper into "Diff-in-Diff" Monday, 11/21

Mastering 'Metrics: Chapter 5

Concepts: placebo variables, serial correlation, clustered errors

No class (Thanksgiving Break) Wednesday, 11/23

Homework #6 due.

Lab #6 due.

Finding *Front* Doors Monday, 11/28

Concepts: front door criterion, seemingly unrelated regression

Mediation and Mechanisms Wednesday, 11/30

Concepts: mediators, direct and indirect effects, "conditioning" vs "holding constant"

Dedicated to term paper help Monday, 12/5

Dedicated to term paper help Wednesday, 12/7

Homework #7 due.

Lab #7 due.

Exam 3 Review Session Monday, 12/12

Term paper due.

Exam 3: Research Design (self-scheduled)