Lecture 1:
Welcome to Econometrics II

January 14, 2026

Welcome

Goal of this course is twofold

Help you read research

- Are these the right data?
- Is this the right method?
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Help you create research

- Ask a causal question
- Develop a technique to approximate a causal analysis
- Create tests for the validity of your work

Course Administration

1. Syllabus
2. In-class discussion
3. TA Natalia
4. TA sessions on days indicated
5. Handouts
   - summary instructions
   - replication proposal handout
   - problem set 1
6. Random assignment to presentation dates

Expectations

- PhD level class
- responsible for a fair amount of learning on your own
  - choosing relevant paper
  - learning coding as you need: we do not teach Stata
  - intellectual creativity
- you must do the reading – class does not work if you do not
- use the resources I've linked online to learn some Stata
- Use other resources to learn R – see my other class

Introductions

Tell us

- name
- school
- degree
- work, if any
- why this class
- what you want to do when you're done

Lecture 1 Plan

1. The causal problem
2. Randomization
3. Some key terms
4. Experimental vs observational evidence
5. Regression as a conditional expectation function
6. Omitted variable bias in terms of regression coefficients

Defining the Problem

The Whole Semester

We talk about the **causal impact** of a **treatment** on an **outcome**.

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Causal impact: an impact on the outcome **because** of the treatment.

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- Define Mr. i's outcome in the world where he does not get treatment as Y_{0i}
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Bottom line: $Y_{1i} - Y_{0i}$ is fundamentally unobservable.

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No, lots of people don't solve the problem.

Defining Treatment

- Let D_i be the treatment
- Let $D_i \in \{0, 1\}$
- We usually assume a binary treatment for ease of analysis

$$D_i = \begin{cases} 1 & \text{if treated} \\ 0 & \text{if not treated} \end{cases}$$

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- $E[Y_i|D_i = 1]$
  - the average outcome for units for which $D_i = 1$
- $E[Y_i|X = x]$
  - the population average outcome for units where variable X is equal to x
  - for example, average height (Y_i) for people whose hair is curly $(X = x)$

Re-writing the Problem of Interest

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That is, we only see treated outcomes for treated people and untreated outcomes for untreated people.

Now Assume a Constant Treatment Effect

Assume that the effect of treatment D is the same for every person, treated or not. When might this be the case?

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To be clear, this implies

$$Y_{1i} = \kappa + Y_{0i}$$

Assuming a Constant Treatment Effect Makes Selection Bias Easy to See

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Red term is difference in outcome Y for treated relative to untreated in the absence of treatment: **selection bias**.

How Randomization Solves the Problem

Remember the Problematic Term

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For a specific definition of “enough” you need a power analysis – take a different class.

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So we compare observed characteristics across the two groups and **assume** that if those do not differ, the unobserved characteristics do not differ.
Put differently,

$$\text{Avg}_n[Y_{0i}|D_i = 1] = \text{Avg}_n[Y_{0i}|D_i = 0]$$

Likelihood of treatment is independent of outcome in the untreated state.

Some Key Terms

Key Terms and Concepts

1. unit of observation
2. identification
3. matrix algebra notation

The Unit of Observation and Unit of Analysis

The unit of observation is

- the level of the individual unit that you observe
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The unit of observation is a **big deal**

- results differ by unit of observation
- flawed understanding of unit of observation can ruin analysis
- Social Security: you can estimate between 13 and 22 percent of people over 55 get their income solely from social security, depending upon the unit of observation
- sidebar: which gives the lower number, persons or families? See nice handout here.

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- What identifies this result?
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"Identification" means the random variation that yields a causal result.

"Identification strategy" is a strategy for finding a causal effect with a non-randomized treatment

Matrix Algebra Notation

- You do not need to know matrix algebra for this class
  - though if you want to be more serious, it's not a bad idea
- But some papers will use this notation
- I'd like you to be slightly familiar with it

A Vector of Outcomes

- In your previous class, you probably talked a lot about y_i, or an outcome for Mr. i.
- You may have written $\sum_{i=1}^{N} y_i$, where N is the number of people in the population
- in this class, you will frequently see just Y, which is

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ \dots \\ y_N \end{bmatrix}$$

A Vector of Covariates

You may remember that Mr. i has a vector of covariates associated with him: $(x_{1i}, x_{2i}, \ldots, x_{Ki})$, where K is the number of covariates

$$X = \begin{bmatrix} x_{11} & x_{21} & \ldots & x_{K1} \\ x_{12} & x_{22} & \ldots & x_{K2} \\ \vdots & \vdots & \vdots & \vdots \\ x_{1N} & x_{2N} & \ldots & x_{KN} \end{bmatrix}$$

Putting These Together

We can therefore also rewrite the regression equation you know as

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_K x_{Ki} + \epsilon_i$$

as

$$Y = X\beta + e$$

where

$$\beta = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_K \end{bmatrix}$$

Next Lecture

- Start looking for an article to replicate – be aware that this can take some time
- Read *MM* Chapter 2
- Read Black article on webpage, pages as noted