

Introduction

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What is
Econometrics?

Examples

Causality

Potential Outcomes

Examples

References

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1 What is Econometrics? Examples

2 Causality Potential Outcomes Examples

Introduction

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Examples

Causality

Potential Outcomes

Examples

References

Section 1

What is Econometrics?

What is Econometrics?

Econometrics is concerned with the development of statistical methods for:

- Estimation of economic relationships
- Testing of economic theories
- Forecasting of important economic variables
- Evaluation of government and business policy

Why statistics?

- Economic theory is used to construct models characterizing relationships between variables of interest
- Economic models are only approximations
- A model can take into account a number of important factors but there will be many factors left out that also affect outcomes
- We therefore replace the exact (deterministic) model with a probabilistic model

Example: Mincer's (1974) wage regression

- Economic Model: wage depends on human capital

$$\text{wage} = f(\text{educ}, \text{exper}, \text{training})$$

- Econometric Model:

$$\log(\text{wage}) = \beta_0 + \beta_1 \text{educ} + \beta_2 \text{exper} + \beta_3 (\text{exper})^2 + \beta_4 \text{training} + u$$

The term u captures unobserved factors:

- innate ability,
 - family background,
 - quality of education
- Hypothesis Testing: whether training affects wage
 $H_0 : \beta_4 = 0$

Example: Becker's (1968) economic model of crime

- Economic Model: the reward from property crime vs. the cost

$$y = f(x_1, x_2, x_3, x_4, \dots)$$

- y = hours spent in criminal activities (crime)
- x_1 = wage for an hour spent in criminal activities
- x_2 = wage in legal employment (wagem)
- x_3 = income other than from crime or employment (othinc)
- x_4 = probability of getting caught (freqarr)
- Econometric Model:

$$\text{crime} = \beta_0 + \beta_1 \text{wagem} + \beta_2 \text{othinc} + \beta_3 \text{freqarr} + u$$

The term u captures unobserved factors such as:

- the reward for criminal activity,
- family background,
- measurement error

Introduction

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What is
Econometrics?

Examples

Causality

Potential Outcomes

Examples

References

Section 2

Causality

Causality

- We are interested in causal relations, but statistics only allows us to establish correlations
- To say that one variable has a causal effect on another, other factors affecting the outcome must be held fixed
- Sometimes can use controlled experiments
- Experiment are often impossible in economics (too costly and/or for ethical reasons)
- Must rely on observational data

- Example: effect of health insurance coverage on health
- Question: what is the effect of health insurance on health?
- Ideal experiment: randomly give people health insurance or not, compare their health afterward
- Observed survey data:

Group	Sample Size	Mean Health	Std.Dev.
Some insurance	8114	4.01	0.93
No insurance	1281	3.70	1.01

Source: 2009 NHIS data reported by [Angrist and Pischke \(2014\)](#)

- Is $4.01 - 3.70 = 0.31$ the causal effect of health insurance on health?
- Not likely, people with and without insurance differ in other ways that might affect health

Group	Mean Education	Mean income
Some insurance	14.31	106,467
No insurance	11.56	45,656

Potential Outcomes

- Potential outcomes (aka the Rubin causal model) are one powerful way of thinking about causality
- Let $D_i = 1$ if person i has health insurance, 0 otherwise
- Let Y_{i0} and Y_{i1} be the **potential outcomes**
 - Y_{i0} = health if person i does not have health insurance
 - Y_{i1} = health if person i has health insurance
- We observe

$$\begin{aligned}
 Y_i &= \begin{cases} Y_{i0} & \text{if } D_i = 0 \\ Y_{i1} & \text{if } D_i = 1 \end{cases} \\
 &= (1 - D_i)Y_{i0} + D_iY_{i1} \\
 &= Y_{i0} + D_i \times \underbrace{(Y_{i1} - Y_{i0})}
 \end{aligned}$$

causal effect of health insurance for person i

Potential Outcomes (continued)

- Observed average difference in health

$$\begin{aligned}
 E[Y_{i1}|D_i = 1] - E[Y_{i0}|D_i = 0] &= \\
 &= \underbrace{E[Y_{i1} - Y_{i0}|D_i = 1]}_{\text{Average treatment effect on the treated}} + \\
 &\quad + \underbrace{E[Y_{i0}|D_i = 1] - E[Y_{i0}|D_i = 0]}_{\text{Selection bias}}
 \end{aligned}$$

- Insurance may help you or hurt you (on average), but wealthier people are more likely to afford insurance and might be healthier for other reasons; conversely people who are sick might be more willing to pay for insurance
- Random assignment of D_i removes selection bias because D_i and Y_{i0} are then independent
- Often cannot randomize, but can
 - Use available data to approximate desired experiment
 - Use economic theory to impose restrictions

Examples

- **Education**

$$\log(\text{Wage}) = \alpha + \beta \times \text{Years of Schooling} + U,$$

U = other factors, for example, ability. Since it is very hard to control for ability, one can overestimate the return to education by relying on usual correlations.

- **Minimum wage and employment** (Card and Krueger *AER* 1994)

$$\text{Unemployment} = \beta_0 + \beta_1 \times \text{Minimum Wage} + U$$

Reverse causality: High employment may lead to political pressure for higher minimum wage.

Examples (continued)

- **Size of the police force and crime**

$$\text{Number of Crimes} = \alpha + \beta \times \text{Size of the Police Force} + U$$

Usually, cities with a lot of criminal activity have a bigger police force. Simple correlations can spuriously indicate that the size of the police force has a positive effect on the crime rates.

References

Angrist, Joshua D and Jörn-Steffen Pischke. 2014. *Mastering 'Metrics: The Path from Cause to Effect*. Princeton University Press.