Causal Inference Basics

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Outline

1. Introduction
2. Core Concepts
3. References

What is Causal Inference?

Definition

Causal inference is the process of drawing conclusions about causal relationships based on observed data [1].

Key Question

What would have happened to Y if we had changed X by one unit, while holding everything else constant?

Why Causal Inference Matters

- **Policy Evaluation**: Understanding the effect of interventions
- **Scientific Discovery**: Identifying causal mechanisms
- **Decision Making**: Making informed choices under uncertainty

Example: Does taking a drug actually cure the disease, or is it just correlation?

Potential Outcomes Framework

Let Y_{1i} and Y_{0i} denote the potential outcomes for unit i:

$$Y_{1i} = \text{Outcome if treated}$$
$$Y_{0i} = \text{Outcome if not treated}$$

The causal effect for unit i is:

$$\tau_i = Y_{1i} - Y_{0i} \tag{1}$$

Problem: We can only observe one of these for each unit!

Average Treatment Effect (ATE)

The average causal effect across the population:

$$\text{ATE} = \mathbb{E}[Y_{1i} - Y_{0i}] \tag{2}$$

Fundamental Problem of Causal Inference

We cannot observe Y_{1i} and Y_{0i} simultaneously for the same unit i.

References I


Joshua D. Angrist and Jörn-Steffen Pischke.
Mostly Harmless Econometrics: An Empiricist's Companion.
Princeton University Press, Princeton, NJ, 2009.

Thank You!

Questions?