

# **PSC4375: Introduction to Causality**

## **Week 1: Lecture 1**

Prof. Weldzius

Villanova University

Slides Updated: 2025-01-21

# What is a causal effect?

**Factual** vs. **Counterfactual**

# What is a causal effect?

## Factual vs. Counterfactual

- Does the minimum wage increase the unemployment rate?

# What is a causal effect?

## Factual vs. Counterfactual

- Does the minimum wage increase the unemployment rate?
  - Unemployment rate went up after the minimum wage increased
  - Would it have gone up if the minimum wage increase not occurred?

# What is a causal effect?

## Factual vs. Counterfactual

- Does the minimum wage increase the unemployment rate?
  - Unemployment rate went up after the minimum wage increased
  - Would it have gone up if the minimum wage increase not occurred?
- Does having girls affect a judge's rulings in court?

# What is a causal effect?

## Factual vs. Counterfactual

- Does the minimum wage increase the unemployment rate?
  - Unemployment rate went up after the minimum wage increased
  - Would it have gone up if the minimum wage increase not occurred?
- Does having girls affect a judge's rulings in court?
  - A judge with a daughter gave a pro-choice ruling.
  - Would they have done that if had a son instead?

# What is a causal effect?

## Factual vs. Counterfactual

- Does the minimum wage increase the unemployment rate?
  - Unemployment rate went up after the minimum wage increased
  - Would it have gone up if the minimum wage increase not occurred?
- Does having girls affect a judge's rulings in court?
  - A judge with a daughter gave a pro-choice ruling.
  - Would they have done that if had a son instead?
- **Fundamental problem of causal inference:**

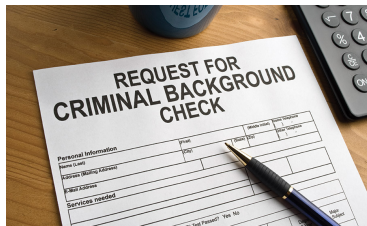
# What is a causal effect?

## Factual vs. Counterfactual

- Does the minimum wage increase the unemployment rate?
  - Unemployment rate went up after the minimum wage increased
  - Would it have gone up if the minimum wage increase not occurred?
- Does having girls affect a judge's rulings in court?
  - A judge with a daughter gave a pro-choice ruling.
  - Would they have done that if had a son instead?
- **Fundamental problem of causal inference:**
  - Can never observe counterfactuals, must be inferred.



# Criminal record experiment



- Does having a criminal record affect job prospects?
- Experimental setting:
  - Randomly assign 4 hired “confederates” (2 White, 2 Black) to apply to different jobs in Milwaukee.
  - Men were matched on physical appearance, self-presentation, age, etc.
  - Confederates would alternate indicating they had a criminal record.
- Outcome of interest: receiving a callback from a potential employer.

# A tale of two applications

	Criminal Record	Callback?
Applicant 1		
Applicant 2		

- Did the first applicant not callback the applicant **because** they had a criminal record?

# Notation and Jargon

- **Unit** (indexed by  $i$ ): job application for employer
- **Treatment variable**  $T_i$ : criminal record or not
- **Treatment group** (treated units): applications with criminal record
- **Control group** (untreated units): applications without criminal record
- **Outcome variable**  $Y_i$ : callback

	$T_i$ (ex-felon)	$Y_i$ (callback)
Ex-felon applicant	1	0
Non-ex-felon applicant	0	1

# Causal effects and counterfactuals

- What does “ $T_i$  causes  $Y_i$ ” mean?  $\rightsquigarrow$  **counterfactuals**, “what if”
- Would an employer treat criminal & noncriminal applicants differently?
- Two **potential outcomes**:
  - $Y_i(1)$ : would applicant  $i$  get a callback if applied as an ex-felon?
  - $Y_i(0)$ : would applicant  $i$  get a callback if applied not as an ex-felon?
- **Causal effect**:  $Y_i(1) - Y_i(0)$ 
  - $Y_i(1) - Y_i(0) = 0 \rightsquigarrow$  criminal record has no impact on callback
  - $Y_i(1) - Y_i(0) = -1 \rightsquigarrow$  criminal record prevents callback
  - $Y_i(1) - Y_i(0) = +1 \rightsquigarrow$  criminal record leads to callback

# Potential Outcomes

	$T_i$ (ex-felon)	$Y_i$ (callback)	$Y_i(1)$	$Y_i(0)$
Ex-felon applicant	1	0	0	???
Non-ex-felon applicant	0	1	???	1

- **Fundamental problem of causal inference:**

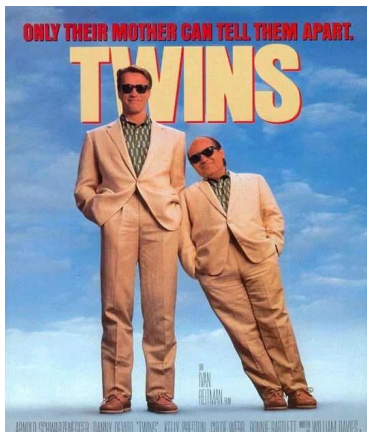
- We only observe one of the two potential outcomes.
- Observe  $Y_i = Y_i(1)$  if  $T_i = 1$  or  $Y_i = Y_i(0)$  if  $T_i = 0$
- To infer causal effect, we need to infer the missing counterfactuals!

# How can we figure out counterfactuals?



- Find a similar unit!  $\rightsquigarrow$  **matching**
  - Mill's method of difference
- Did applicant fail to get a job offer because of his criminal record?
  - $\rightsquigarrow$  find a non-ex-felon who is just like ex-felon applicant.
- NJ increased the minimum wage. Causal effect on unemployment?
  - $\rightsquigarrow$  find a state similar to NJ that didn't increase minimum wage.

# Imperfect matches



- The problem: imperfect matches!
- Say we match  $i$  (treated) and  $j$  (control)
- **Selection Bias:**  $Y_i(1) \neq Y_j(1)$
- Those who take treatment may be different than those who take control.
- How can we correct for that?