

Name: _____

In-Class Activity: Experiments

PS200C: Causal Inference in the Social Sciences
Spring 2026

1. From ATE to the Difference in Means

Suppose treatment D_i is randomly assigned, so that $\{Y_i(1), Y_i(0)\} \perp\!\!\!\perp D_i$.

Starting from the ATE, fill in the missing expressions and justify each step.

$$\begin{aligned}\tau_{\text{ATE}} &= \mathbb{E}[Y_i(1)] - \mathbb{E}[Y_i(0)] \\ &= \mathbb{E}[Y_i(_) \mid D_i = _] - \mathbb{E}[Y_i(_) \mid D_i = _] \quad \text{ignorability} \\ &= \mathbb{E}[_ \mid D_i = 1] - \mathbb{E}[_ \mid D_i = 0] \quad \text{consistency} \\ &\approx \bar{Y}_1 - \bar{Y}_0\end{aligned}$$

2. Selection bias and randomization

Recall from the POM lecture that the difference in means can be decomposed as:

$$\mathbb{E}[Y_i \mid D_i = 1] - \mathbb{E}[Y_i \mid D_i = 0] = \underbrace{\mathbb{E}[Y_i(1) - Y_i(0) \mid D_i = 1]}_{\text{ATT}} + \underbrace{\mathbb{E}[Y_i(0) \mid D_i = 1] - \mathbb{E}[Y_i(0) \mid D_i = 0]}_{\text{Selection Bias}}$$

(a) In words, what does the selection bias term measure?

(b) Why does random assignment of D_i eliminate this term?

(c) Once the bias term is zero, the DIM equals the ATT. Why does it also equal the ATE under randomization?

3. Sharp null and randomization inference

Consider this table of observed data from a small experiment with 2 treated and 2 control units:

i	D_i	Y_i
1	1	8
2	1	4
3	0	3
4	0	5

(a) What is the observed difference in means, $\hat{\tau}$?

(b) Under the sharp null $H_0 : Y_i(1) = Y_i(0)$ for all i , fill in $Y_i(1)$ and $Y_i(0)$ for every unit:

i	D_i	Y_i	$Y_i(1)$	$Y_i(0)$
1	1	8	_____	_____
2	1	4	_____	_____
3	0	3	_____	_____
4	0	5	_____	_____

(c) There are $\binom{4}{2} = 6$ possible assignments. Fill in $\hat{\tau}(\omega)$ for each, then compute the two-sided p-value.

Treated units	$\hat{\tau}(\omega)$
{1, 2}	_____
{1, 3}	_____
{1, 4}	_____
{2, 3}	_____
{2, 4}	_____
{3, 4}	_____

Two-sided p-value: _____