

Gov 50: 7. Randomized Experiments

Matthew Blackwell

Harvard University

Roadmap

1. Randomized experiments
2. Calculating effects

Causal effects & counterfactuals

- What does “ T_i causes Y_i ” mean? \rightsquigarrow **counterfactuals**, “what if”
- Would respondent change their support based on the conversation?
- Two **potential outcomes**:
 - $Y_i(1)$: would respondent i support ND laws if they had trans rights script?
 - $Y_i(0)$: would respondent i support ND laws if they had recycling script?
- **Causal effect**: $Y_i(1) - Y_i(0)$
 - $Y_i(1) - Y_i(0) = 0 \rightsquigarrow$ script has no effect on policy views
 - $Y_i(1) - Y_i(0) = -1 \rightsquigarrow$ trans rights script lower support for laws
 - $Y_i(1) - Y_i(0) = +1 \rightsquigarrow$ trans rights script increases support for laws

Potential outcomes

i	T_i	Y_i	$Y_i(1)$	$Y_i(0)$
Respondent 1	0	0	???	0
Respondent 2	1	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
- Does respondent support law because of the trans rights script?
 - \rightsquigarrow find a identical respondent who got the recycling script.
- 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?

1/ Randomized experiments

Match groups not individuals



- **Randomized control trial:** each unit's treatment assignment is determined by chance.
 - Flip a coin; draw red and blue chips from a hat; etc
- Randomization ensures **balance** between treatment and control group.
 - Treatment and control group are identical **on average**
 - Similar on both observable and unobservable characteristics.

A little more notation

- We will often refer to the **sample size** (number of units) as n .
- We often have n measurements of some variable: (Y_1, Y_2, \dots, Y_n)
- How many in our sample support nondiscrimination laws?

$$Y_1 + Y_2 + Y_3 + \dots + Y_n$$

- Notation is a bit clunky, so we often use the **Sigma notation**:

$$\sum_{i=1}^n Y_i = Y_1 + Y_2 + Y_3 + \dots + Y_n$$

- $\sum_{i=1}^n$ means sum each value from Y_1 to Y_n

Averages

- The **sample average** or **sample mean** is simply the sum of all values divided by the number of values.
- Sigma notation allows us to write this in a compact way:

$$\bar{Y} = \frac{1}{n} \sum_{i=1}^n Y_i$$

- Suppose we surveyed 6 people and 3 supported nondiscrim. laws:

$$\bar{Y} = \frac{1}{6} (1 + 1 + 1 + 0 + 0 + 0) = 0.5$$

Quantity of interest

- We want to estimate the average causal effects over all units:

$$\begin{aligned}\text{Sample Average Treatment Effect (SATE)} &= \frac{1}{n} \sum_{i=1}^n \{Y_i(1) - Y_i(0)\} \\ &= \frac{1}{n} \sum_{i=1}^n Y_i(1) - \frac{1}{n} \sum_{i=1}^n Y_i(0)\end{aligned}$$

- Why can't we just calculate this quantity directly?
- What we can estimate instead:

$$\text{Difference in means} = \bar{Y}_{\text{treated}} - \bar{Y}_{\text{control}}$$

- \bar{Y}_{treated} : sample average outcome for treated group
- \bar{Y}_{control} : sample average outcome for control group
- When will the difference-in-means is a good estimate of the SATE?

Why randomization works

- Under an RCT, treatment and control groups are random samples.
- Average in the treatment group will be similar to average if all treated:

$$\bar{Y}_{\text{treated}} \approx \frac{1}{n} \sum_{i=1}^n Y_i(1)$$

- Average in the control group will be similar to average if all untreated:

$$\bar{Y}_{\text{control}} \approx \frac{1}{n} \sum_{i=1}^n Y_i(0)$$

- Implies difference-in-means should be close to SATE:

$$\bar{Y}_{\text{treated}} - \bar{Y}_{\text{control}} \approx \frac{1}{n} \sum_{i=1}^n Y_i(1) - \frac{1}{n} \sum_{i=1}^n Y_i(0) = \frac{1}{n} \sum_{i=1}^n \{Y_i(1) - Y_i(0)\} = \text{SATE}$$

Some potential problems with RCTs

- **Placebo effects:**

- Respondents will be affected by any intervention, even if they shouldn't have any effect.
- Reason to have control group be recycling script

- **Hawthorne effects:**

- Respondents act differently just knowing that they are under study.

Balance checking

- Can we determine if randomization “worked”?
- If it did, we shouldn’t see large differences between treatment and control group on **pretreatment variable**.
 - Pretreatment variable are those that are unaffected by treatment.
- We can check in the actual data for some pretreatment variable X
 - \bar{X}_{treated} : average value of variable for treated group.
 - \bar{X}_{control} : average value of variable for control group.
 - Under randomization, $\bar{X}_{\text{treated}} - \bar{X}_{\text{control}} \approx 0$

Multiple treatments

- Instead of 1 treatment, we might have multiple **treatment arms**:
 - Control condition
 - Treatment A
 - Treatment B
 - Treatment C, etc
- In this case, we will look at multiple comparisons:
 - $\bar{Y}_{\text{treated, A}} - \bar{Y}_{\text{control}}$
 - $\bar{Y}_{\text{treated, B}} - \bar{Y}_{\text{control}}$
 - $\bar{Y}_{\text{treated, A}} - \bar{Y}_{\text{treated, B}}$
- If treatment arms are randomly assigned, these differences will be good estimators for each causal contrast.

2/ Calculating effects

Transphobia study data

```
## reinstall gov50data if necessary  
library(gov50data)
```

Variable Name	Description
age	Age of the R in years
female	1=R marked “Female” on voter reg., 0 otherwise
voted_gen_14	1 if R voted in the 2014 general election
vote_gen_12	1 if R voted in the 2012 general election
treat_ind	1 if R assigned to trans rights script, 0 for recycling
racename	name of racial identity indicated on voter file
democrat	1 if R is a registered Democrat
nondiscrim_pre	1 if R supports nondiscrim. law at baseline
nondiscrim_post	1 if R supports nondiscrim. law after 3 months

Peak at the data

```
trans
```

```
## # A tibble: 565 x 9
##   age female voted_gen_14 voted_gen_12 treat_ind racename
##   <dbl> <dbl>         <dbl>         <dbl>         <dbl> <chr>
## 1    29      0           0           1           0 African~
## 2    59      1           1           0           1 African~
## 3    35      1           1           1           1 African~
## 4    63      1           1           1           1 African~
## 5    65      0           1           1           1 African~
## 6    51      1           1           1           0 Caucasi~
## 7    26      1           1           1           0 African~
## 8    62      1           1           1           1 African~
## 9    37      0           1           1           0 Caucasi~
## 10   51      1           1           1           0 Caucasi~
## # i 555 more rows
## # i 3 more variables: democrat <dbl>, nondiscrim_pre <dbl>,
## #   nondiscrim_post <dbl>
```

Calculate the average outcomes in each group

```
treat_mean <- trans |>
  filter(treat_ind == 1) |>
  summarize(nondiscrim_mean = mean(nondiscrim_post))
treat_mean
```

```
## # A tibble: 1 x 1
##   nondiscrim_mean
##             <dbl>
## 1             0.687
```

```
control_mean <- trans |>
  filter(treat_ind == 0) |>
  summarize(nondiscrim_mean = mean(nondiscrim_post))
control_mean
```

```
## # A tibble: 1 x 1
##   nondiscrim_mean
##             <dbl>
## 1             0.648
```

Calculating the difference in means

```
treat_mean - control_mean
```

```
## nondiscrim_mean
```

```
## 1 0.039
```

We'll see more ways to do this throughout the semester.

Checking balance on numeric covariates

We can use `group_by` to see how the mean of covariates varies by group:

```
trans |>  
  group_by(treat_ind) |>  
  summarize(age_mean = mean(age))
```

```
## # A tibble: 2 x 2  
##   treat_ind age_mean  
##       <dbl>   <dbl>  
## 1         0     48.2  
## 2         1     48.3
```

Checking balance on categorical covariates

Or we can group by treatment and a categorical control:

```
trans |>
  group_by(treat_ind, racename) |>
  summarize(n = n())
```

```
## # A tibble: 9 x 3
## # Groups:   treat_ind [2]
##   treat_ind racename          n
##   <dbl> <chr>          <int>
## 1      0 African American    58
## 2      0 Asian              2
## 3      0 Caucasian         77
## 4      0 Hispanic        150
## 5      1 African American    68
## 6      1 Asian              4
## 7      1 Caucasian         75
## 8      1 Hispanic        130
## 9      1 Native American     1
```

Hard to read!

pivot_wider

`pivot_wider()` takes data from a single column and moves it into multiple columns based on a grouping variable:

```
trans |>
  group_by(treat_ind, racename) |>
  summarize(n = n()) |>
  pivot_wider(
    names_from = treat_ind,
    values_from = n
  )
```

`names_from` tells us what variable will map onto the columns

`values_from` tell us what values should be mapped into those columns

```
trans |>
  group_by(treat_ind, racename) |>
  summarize(n = n()) |>
  pivot_wider(
    names_from = treat_ind,
    values_from = n
  )
```

```
## # A tibble: 5 x 3
##   racename      `0`    `1`
##   <chr>      <int> <int>
## 1 African American    58    68
## 2 Asian                2     4
## 3 Caucasian          77    75
## 4 Hispanic          150   130
## 5 Native American    NA     1
```


Calculating diff-in-means by group

```
trans |>
  mutate(
    treat_ind = if_else(treat_ind == 1, "Treated", "Control"),
    party = if_else(democrat == 1, "Democrat", "Non-Democrat")
  ) |>
  group_by(treat_ind, party) |>
  summarize(nondiscrim_mean = mean(nondiscrim_post)) |>
  pivot_wider(
    names_from = treat_ind,
    values_from = nondiscrim_mean
  ) |>
  mutate(
    diff_in_means = Treated - Control
  )
```

```
## # A tibble: 2 x 4
```

```
##   party      Control Treated diff_in_means
##   <chr>      <dbl>   <dbl>         <dbl>
## 1 Democrat    0.704    0.754         0.0498
## 2 Non-Democrat 0.605    0.628         0.0234
```

```
## # A tibble: 2 x 4
##   party      Control Treated diff_in_means
##   <chr>      <dbl>   <dbl>         <dbl>
## 1 Democrat    0.704    0.754         0.0498
## 2 Non-Democrat 0.605    0.628         0.0234
```