“Whenever I read statistical reports, I try to imagine my unfortunate contemporary, the Average Person, who, according to these reports, has 0.66 children, 0.032 cars, and 0.046 TVs.” — Kató Lomb
By the end of section today, you should:

- Be able to conduct and interpret a difference of proportions test
- Be able to explain the following for “The Colbert Bump”
  - Research question
  - Key confound
  - Method for addressing the confound
  - Key result
- Know the Stata commands relevant for Homework 2
 Warm Up

- Name

Pew Research Center recently conducted a survey of a national sample of 1,503 adults, 18 years of age or older, living in the United States. The results indicated that 29% of respondents reported that the new tax law will have a mostly positive effect on them and their families over the coming years.

What is the 95% confidence interval for the percentage of U.S. adults who think that the new tax law will have a mostly positive effect on them and their families over the coming years?

\[ \hat{p} \pm 2 \times \sqrt{\frac{\hat{p}(1-\hat{p})}{N}} \]
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\[
\hat{p} \pm 2 \times \sqrt{\frac{(\hat{p})(1-\hat{p})}{N}}
\]

\[
.29 \pm 2 \times \sqrt{\frac{(.29)(1-.29)}{1503}}
\]

\[
.29 \pm 2 \times \sqrt{\frac{.2059}{1503}}
\]

\[
.29 \pm 2 \times \sqrt{0.00014}
\]

\[
.29 \pm 2 \times 0.012
\]

\[
.29 \pm 0.024
\]

\[
(.266, .314)
\]

\[
(26.6\%, 31.4\%)
\]
Difference of Proportions

But what if we wanted to know if Democrats and Republicans have different opinions about the new tax law?
But what if we wanted to know if Democrats and Republicans have different opinions about the new tax law?

Americans are divided on how tax law will affect them and the country

% who say the tax law will have a ___ effect over the coming years...

On you and your family

<table>
<thead>
<tr>
<th></th>
<th>Mostly positive</th>
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Difference of Proportions Test: Write Hypotheses

Null Hypothesis ($H_0$): There is no difference in opinion between Democrats and Republicans

$$\hat{p}_{Republican} - \hat{p}_{Democrat} = 0$$

Alternative Hypothesis ($H_1$): There is a difference in opinion between Democrats and Republicans

$$\hat{p}_{Republican} - \hat{p}_{Democrat} \neq 0$$
Null Hypothesis ($H_0$): There is no difference in opinion between Democrats and Republicans
Null Hypothesis ($H_0$): There is no difference in opinion between Democrats and Republicans

\[ \hat{p}_{\text{Republican}} - \hat{p}_{\text{Democrat}} = 0 \]
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Difference of Proportions Test: Write Hypotheses

- Null Hypothesis $(H_0)$: There is no difference in opinion between Democrats and Republicans
  \[ \hat{p}_{\text{Republican}} - \hat{p}_{\text{Democrat}} = 0 \]

- Alternative Hypothesis $(H_1)$: There is a difference in opinion between Democrats and Republicans
  \[ \hat{p}_{\text{Republican}} - \hat{p}_{\text{Democrat}} \neq 0 \]
Difference of Proportions Test: Check the Data

Does our hypothesis appear to hold?

52 - .13 = .39 ≠ 0

Yes
Difference of Proportions Test: Check the Data

Americans are divided on how tax law will affect them and the country

% who say the tax law will have a ___ effect over the coming years...

On you and your family

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Difference of Proportions Test: Check the Data

Does our hypothesis appear to hold?

Americans are divided on how tax law will affect them and the country

% who say the tax law will have a ___ effect over the coming years...

- Mostly positive
- Not much effect
- Mostly negative
- DK

On you and your family

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Does our hypothesis appear to hold? \( .52 - .13 = .39 \)
Difference of Proportions Test: Check the Data

Does our hypothesis appear to hold? \(0.52 - 0.13 = 0.39 \neq 0\)
Difference of Proportions Test: Check the Data

Americans are divided on how tax law will affect them and the country

% who say the tax law will have a ___ effect over the coming years...

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Does our hypothesis appear to hold? \(.52 - .13 = .39 \neq 0\) Yes
Difference of Proportions Test: Test for Significance

$\left( \hat{p}_{\text{Rep}} - \hat{p}_{\text{Dem}} \right) \pm 2 \times \sqrt{\left( \text{std. error Rep} \right)^2 + \left( \text{std. error Dem} \right)^2}$

$\hat{p}_{\text{Rep}}$ = Proportion of Republicans with positive opinion

$\hat{p}_{\text{Dem}}$ = Proportion of Democrats with positive opinion

$\text{std. error Rep}$ = Standard Error for Republicans:

$\sqrt{\hat{p}_{\text{Rep}}(1-\hat{p}_{\text{Rep}})} / \sqrt{N_{\text{Rep}}}$

$\text{std. error Dem}$ = Standard Error for Democrats:

$\sqrt{\hat{p}_{\text{Dem}}(1-\hat{p}_{\text{Dem}})} / \sqrt{N_{\text{Dem}}}$

$N_{\text{Rep}}$ = Number of Republicans in the sample

$N_{\text{Dem}}$ = Number of Democrats in the sample
Difference of Proportions Test: Test for Significance

\[(\hat{p}_{Rep} - \hat{p}_{Dem})\]
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm \\
\pm 2 \times \sqrt{\frac{\hat{p}_{Rep}(1 - \hat{p}_{Rep})}{N_{Rep}} + \frac{\hat{p}_{Dem}(1 - \hat{p}_{Dem})}{N_{Dem}}}
\]

\(\hat{p}_{Rep}\) = Proportion of Republicans with positive opinion

\(\hat{p}_{Dem}\) = Proportion of Democrats with positive opinion

std. error Rep = Standard Error for Republicans:

\[\sqrt{\hat{p}_{Rep}(1 - \hat{p}_{Rep})} \times \frac{1}{\sqrt{N_{Rep}}}
\]

std. error Dem = Standard Error for Democrats:

\[\sqrt{\hat{p}_{Dem}(1 - \hat{p}_{Dem})} \times \frac{1}{\sqrt{N_{Dem}}}
\]

\(N_{Rep}\) = Number of Republicans in the sample

\(N_{Dem}\) = Number of Democrats in the sample
\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2*
\]
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{\left(\text{std. error}_{Rep}\right)^2 + \left(\text{std. error}_{Dem}\right)^2}
\]

\(\hat{p}_{Rep}\) = Proportion of Republicans with positive opinion

\(\hat{p}_{Dem}\) = Proportion of Democrats with positive opinion

\(\text{std. error}_{Rep}\) = Standard Error for Republicans:

\[
\sqrt{\hat{p}_{Rep}(1 - \hat{p}_{Rep})/N_{Rep}}
\]

\(\text{std. error}_{Dem}\) = Standard Error for Democrats:

\[
\sqrt{\hat{p}_{Dem}(1 - \hat{p}_{Dem})/N_{Dem}}
\]

\(N_{Rep}\) = Number of Republicans in the sample

\(N_{Dem}\) = Number of Democrats in the sample
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2\sqrt{\left(\text{std. error}_{Rep}\right)^2 + \left(\text{std. error}_{Dem}\right)^2}
\]

- \(\hat{p}_{Rep} = \text{Proportion of Republicans with positive opinion}\)
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(\text{std. error}_{Rep})^2 + (\text{std. error}_{Dem})^2}
\]

- \(\hat{p}_{Rep}\) = Proportion of Republicans with positive opinion
- \(\hat{p}_{Dem}\) = Proportion of Democrats with positive opinion
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \cdot \sqrt{(std.\ error_{Rep})^2 + (std.\ error_{Dem})^2}
\]

- \(\hat{p}_{Rep}\) = Proportion of Republicans with positive opinion
- \(\hat{p}_{Dem}\) = Proportion of Democrats with positive opinion
- \(std.\ error_{Rep}\) = Standard Error for Republicans:
  \[
  \frac{\sqrt{(\hat{p}_{Rep})(1-\hat{p}_{Rep})}}{\sqrt{N_{Rep}}}
  \]
- \(std.\ error_{Dem}\) = Standard Error for Democrats:
  \[
  \frac{\sqrt{(\hat{p}_{Dem})(1-\hat{p}_{Dem})}}{\sqrt{N_{Dem}}}
  \]
Difference of Proportions Test: Test for Significance

\[(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(\text{std. error}_{Rep})^2 + (\text{std. error}_{Dem})^2}\]

- \(\hat{p}_{Rep} = \text{Proportion of Republicans with positive opinion}\)
- \(\hat{p}_{Dem} = \text{Proportion of Democrats with positive opinion}\)
- \(\text{std. error}_{Rep} = \text{Standard Error for Republicans}:\)
  \[\frac{\sqrt{(\hat{p}_{Rep})(1 - \hat{p}_{Rep})}}{\sqrt{N_{Rep}}}\]
- \(\text{std. error}_{Dem} = \text{Standard Error for Democrats}:\)
  \[\frac{\sqrt{(\hat{p}_{Dem})(1 - \hat{p}_{Dem})}}{\sqrt{N_{Dem}}}\]
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(std.\ error_{Rep})^2 + (std.\ error_{Dem})^2}
\]

- \(\hat{p}_{Rep}\) = Proportion of Republicans with positive opinion
- \(\hat{p}_{Dem}\) = Proportion of Democrats with positive opinion
- \(std.\ error_{Rep}\) = Standard Error for Republicans:
  \[
  \sqrt{(\hat{p}_{Rep})(1-\hat{p}_{Rep})} / \sqrt{N_{Rep}}
  \]
- \(std.\ error_{Dem}\) = Standard Error for Democrats:
  \[
  \sqrt{(\hat{p}_{Dem})(1-\hat{p}_{Dem})} / \sqrt{N_{Dem}}
  \]
- \(N_{Rep}\) = Number of Republicans in the sample
- \(N_{Dem}\) = Number of Democrats in the sample
Difference of Proportions Test: Test for Significance

There were 571 Republicans and 767 Democrats in this sample.
There were 571 Republicans and 767 Democrats in this sample.
Difference in Proportions Test: Test for Significance

- $\hat{p}_{Rep} = .52$
- $\hat{p}_{Dem} = .13$
- $N_{Rep} = 571$
- $N_{Dem} = 767$
\[ \hat{p}_{Rep} = .52 \]
\[ \hat{p}_{Dem} = .13 \]
\[ N_{Rep} = 571 \]
\[ N_{Dem} = 767 \]

**Standard Error for Republicans:**

\[ \frac{\sqrt{\hat{p}_{Rep}(1-\hat{p}_{Rep})}}{\sqrt{N_{Rep}}} \]
\[ \hat{p}_{Rep} = .52 \]
\[ \hat{p}_{Dem} = .13 \]
\[ N_{Rep} = 571 \]
\[ N_{Dem} = 767 \]

**Standard Error for Republicans:**

\[ \frac{\sqrt{\hat{p}_{Rep}(1-\hat{p}_{Rep})}}{\sqrt{N_{Rep}}} = \frac{\sqrt{(.52)(1-.52)}}{\sqrt{571}} = \]
Difference in Proportions Test: Test for Significance

- $\hat{p}_{Rep} = .52$
- $\hat{p}_{Dem} = .13$
- $N_{Rep} = 571$
- $N_{Dem} = 767$

**Standard Error for Republicans:**

\[
\sqrt{\frac{(\hat{p}_{Rep})(1-\hat{p}_{Rep})}{\sqrt{N_{Rep}}}} = \sqrt{\frac{.52(1-.52)}{\sqrt{571}}} = \frac{\sqrt{0.2496}}{\sqrt{571}} \approx
\]
Difference in Proportions Test: Test for Significance

- $\hat{p}_{Rep} = .52$
- $\hat{p}_{Dem} = .13$
- $N_{Rep} = 571$
- $N_{Dem} = 767$

**Standard Error for Republicans:**
\[
\sqrt{\frac{(\hat{p}_{Rep})(1-\hat{p}_{Rep})}{\sqrt{N_{Rep}}}} = \sqrt{\frac{.52)(1-.52)}{\sqrt{571}}} = \frac{\sqrt{0.2496}}{\sqrt{571}} \approx 0.02
\]
\[
\hat{p}_{Rep} = .52 \\
\hat{p}_{Dem} = .13 \\
N_{Rep} = 571 \\
N_{Dem} = 767 
\]

Standard Error for Republicans:

\[
\sqrt{\left( \frac{\hat{p}_{Rep} \cdot (1-\hat{p}_{Rep})}{N_{Rep}} \right)} = \frac{\sqrt{.52 \cdot (1-.52)}}{\sqrt{571}} = \frac{\sqrt{0.2496}}{\sqrt{571}} \approx 0.02
\]

Standard Error for Democrats:
Difference in Proportions Test: Test for Significance

- \( \hat{p}_{Rep} = .52 \)
- \( \hat{p}_{Dem} = .13 \)
- \( N_{Rep} = 571 \)
- \( N_{Dem} = 767 \)

Standard Error for Republicans:

\[
\frac{\sqrt{\hat{p}_{Rep}(1-\hat{p}_{Rep})}}{\sqrt{N_{Rep}}} = \frac{\sqrt{.52(1-.52)}}{\sqrt{571}} = \frac{\sqrt{0.2496}}{\sqrt{571}} \approx 0.02
\]

Standard Error for Democrats:

\[
\frac{\sqrt{\hat{p}_{Dem}(1-\hat{p}_{Dem})}}{\sqrt{N_{Dem}}}
\]
Difference in Proportions Test: Test for Significance

- $\hat{p}_{Rep} = .52$
- $\hat{p}_{Dem} = .13$
- $N_{Rep} = 571$
- $N_{Dem} = 767$

**Standard Error for Republicans:**

$$\frac{\sqrt{\hat{p}_{Rep}(1-\hat{p}_{Rep})}}{\sqrt{N_{Rep}}}=\frac{\sqrt{(.52)(1-.52)}}{\sqrt{571}}=\frac{\sqrt{0.2496}}{\sqrt{571}}\approx 0.02$$

**Standard Error for Democrats:**

$$\frac{\sqrt{\hat{p}_{Dem}(1-\hat{p}_{Dem})}}{\sqrt{N_{Dem}}}=\frac{\sqrt{(.13)(1-.13)}}{\sqrt{767}}=\frac{\sqrt{0.1131}}{\sqrt{767}}\approx 0.01$$
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{\left(\text{std. error}_{Rep}\right)^2 + \left(\text{std. error}_{Dem}\right)^2}
\]

\[
(0.52 - 0.13) \pm 2 \times \sqrt{\left(0.02\right)^2 + \left(0.01\right)^2}
\]

\[
0.39 \pm 2 \times \sqrt{0.0004 + 0.0001}
\]

\[
0.39 \pm 0.022
\]

(0.346, 0.434)

(34.6, 43.4)
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(\text{std. error}_{Rep})^2 + (\text{std. error}_{Dem})^2}
\]
Difference of Proportions Test: Test for Significance

\[(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(\text{std. error}_{Rep})^2 + (\text{std. error}_{Dem})^2}\]

\[.52 - .13\]
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{\text{Rep}} - \hat{p}_{\text{Dem}}) \pm 2 \times \sqrt{(\text{std. error}_{\text{Rep}})^2 + (\text{std. error}_{\text{Dem}})^2}
\]

\[(.52 - .13) \pm 2\]
Difference of Proportions Test: Test for Significance

$$\left( \hat{p}_{Rep} - \hat{p}_{Dem} \right) \pm 2 \times \sqrt{\left( std.\ error_{Rep} \right)^2 + \left( std.\ error_{Dem} \right)^2}$$

$$\left( .52 - .13 \right) \pm 2 \times \sqrt{(.02)^2}$$
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{\text{Rep}} - \hat{p}_{\text{Dem}}) \pm 2 \times \sqrt{(\text{std. error}_{\text{Rep}})^2 + (\text{std. error}_{\text{Dem}})^2}
\]

\[
(.52 - .13) \pm 2 \times \sqrt{(.02)^2 + (.01)^2}
\]
Difference of Proportions Test: Test for Significance

\[(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(\text{std. error}_{Rep})^2 + (\text{std. error}_{Dem})^2}\]

\[(.52 - .13) \pm 2 \times \sqrt{(.02)^2 + (.01)^2}\]

\[.39\]
Difference of Proportions Test: Test for Significance

$\left( \hat{p}_{Rep} - \hat{p}_{Dem} \right) \pm 2 \times \sqrt{(std.\ error_{Rep})^2 + (std.\ error_{Dem})^2}$

$.52 - .13 \pm 2 \times \sqrt{(.02)^2 + (.01)^2}$

$.39 \pm 2 \times \sqrt{.0005}$
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{\text{std. error}_{Rep}^2 + \text{std. error}_{Dem}^2}
\]

\[
(.52 - .13) \pm 2 \times \sqrt{(.02)^2 + (.01)^2}
\]

\[
.39 \pm 2 \times \sqrt{.0004}
\]
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(std.\ error_{Rep})^2 + (std.\ error_{Dem})^2}
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(0.52 - 0.13) \pm 2 \times \sqrt{0.02^2 + 0.01^2}
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.39 \pm 2 \times \sqrt{.0004 + .0001}

.39
Difference of Proportions Test: Test for Significance

\[(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(std.\ error_{Rep})^2 + (std.\ error_{Dem})^2}\]

\[(.52 - .13) \pm 2 \times \sqrt{(.02)^2 + (.01)^2}\]

\.39 \pm 2\times\sqrt{.0004 + .0001}

\.39 \pm 2\times
Difference of Proportions Test: Test for Significance

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(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(std.\ error_{Rep})^2 + (std.\ error_{Dem})^2}
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\[
.39 \pm 2 \times .0005
\]

\[
.39 \pm 2 \times 0.022
\]

\[
.39 \pm 0.044
\]
Difference of Proportions Test: Test for Significance

\[(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(\text{std.error}_{Rep})^2 + (\text{std.error}_{Dem})^2}\]

\[ (.52 - .13) \pm 2 \times \sqrt{(.02)^2 + (.01)^2} \]

\[ .39 \pm 2 \times \sqrt{.0004 + .0001} \]

\[ .39 \pm 2 \times .0005 \]

\[ .39 \pm 2 \times 0.022 \]

\[ .39 \pm 0.044 \]

\[ (0.346, .434) \]
Difference of Proportions Test: Test for Significance

\[
(\hat{p}_{Rep} - \hat{p}_{Dem}) \pm 2 \times \sqrt{(std.\ error_{Rep})^2 + (std.\ error_{Dem})^2}
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\[
0.39 \pm 0.044
\]

\[
(0.346, 0.434)
\]

\[
(34.6, 43.4)
\]
Difference of Proportions Test: Compare with Null Hypothesis

Recall: \( \hat{p}_{\text{Republican}} - \hat{p}_{\text{Democrat}} = 0 \)

Is 0 inside our 95% Confidence Interval? (34.6, 43.4)?

No. Therefore, we can reject the null hypothesis that there is no difference in opinion between Democrats and Republicans. We can conclude with 95% confidence that the true proportion of Democrats with positive opinions about the new tax law is different from the true proportion of Republicans with positive opinions about the new tax law.

We find that a significantly greater proportion of Republicans has positive opinions of the tax law than the proportion of Democrats.
Recall: $\hat{p}_{\text{Republican}} - \hat{p}_{\text{Democrat}} = 0$

Is $0$ inside our 95% Confidence Interval? $(34.6, 43.4)$?

No. Therefore, we can reject the null hypothesis that there is no difference in opinion between Democrats and Republicans. We can conclude with 95% confidence that the true proportion of Democrats with positive opinions about the new tax law is different from the true proportion of Republicans with positive opinions about the new tax law. We find that a significantly greater proportion of Republicans has positive opinions of the tax law than the proportion of Democrats.
Difference of Proportions Test: Compare with Null Hypothesis

Recall: $\hat{p}_{Republican} - \hat{p}_{Democrat} = 0$

Is 0 inside our 95% Confidence Interval? (34.6, 43.4)?

No. Therefore, we can reject the null hypothesis that there is no difference in opinion between Democrats and Republicans. We can conclude with 95% confidence that the true proportion of Democrats with positive opinions about the new tax law is different from the true proportion of Republicans with positive opinions about the new tax law. We find that a significantly greater proportion of Republicans has positive opinions of the tax law than the proportion of Democrats.
Difference of Proportions Test: Compare with Null Hypothesis

Recall: $\hat{p}_{Republican} - \hat{p}_{Democrat} = 0$

Is 0 inside our 95% Confidence Interval? (34.6, 43.4)?

No.
Difference of Proportions Test: Compare with Null Hypothesis

Recall: $\hat{p}_{\text{Republican}} - \hat{p}_{\text{Democrat}} = 0$

Is 0 inside our 95% Confidence Interval? (34.6, 43.4)?

No. Therefore, we can reject the null hypothesis that there is no difference in opinion between Democrats and Republicans. We can conclude with 95% confidence that the true proportion of Democrats with positive opinions about the new tax law is different from the true proportion of Republicans with positive opinions about the new tax law. We find that a significantly greater proportion of Republicans has positive opinions of the tax law than the proportion of Democrats.
Questions??
The Colbert Bump in Campaign Donations: More Truthful than Truthy

James H. Fowler, University of California, San Diego
Research Question: Is the Colbert Bump real? Does going on The Colbert Report cause politicians to become more popular?
The Colbert Bump

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Why is this a problem? What’s the confound?
- Incumbency! Incumbents are more likely to go on the show (IV) and are already more likely to win more votes in the election (DV).
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Solution?
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  - We can’t randomly assign people to come on the show or not...
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Solution?

- We can’t randomly assign people to come on the show or not...
- But we can come close: Matching!
The Colbert Bump: Matching to Hold Confounds Constant

We're going to get a list of all of the politicians who have come on the show and collect some data:

- Incumbent: Yes/No
- Party: Republican/Democrat
- Number of Donations: 0,1,2,3,...
- Amount of Donations: $0, $2, ...

Then, we're going to get a list of all politicians who did not come on the show and find a "twin" or a "match" based on incumbency, party, and donations. This allows us to hold confounds constant to try to isolate the effect of going on the show.
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Democrats who go on the show earn about 44% more in donations in the month after going on the show than Democrats who don't go on the show.

No Colbert Bump for Republicans.

Overall, no evidence of a statistically significant difference in votes between those who went on the show and those who did not.

Fail to reject the null hypothesis that the Colbert Bump is not real.
The Colbert Bump: Conclusions

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To Stata!