Difference in differences: Extensions

INFO/STSCI/ILRST 3900: Causal Inference

7 Nov 2024

Logistics

- Problem set 5 due tonight
  - Only one coding problem
  - Continuity/Smoothness assumption: **potential** outcomes are smooth/continuous **at the cutoff**
- Pset 5 peer reviews released Monday, due Friday
- Pset 6 released next Thurs, due following Thurs (no peer reviews)
- Final Project
  - Submit check-in by Sunday Nov 17th
  - Final paper due Dec 5
  - Video due Dec 18th (asynchronously)

no extensions or flex days... but talk to us if you foresee issues

* note: use your flex days, but if you don't have any left & need an extension, send us an email & we'll consider it

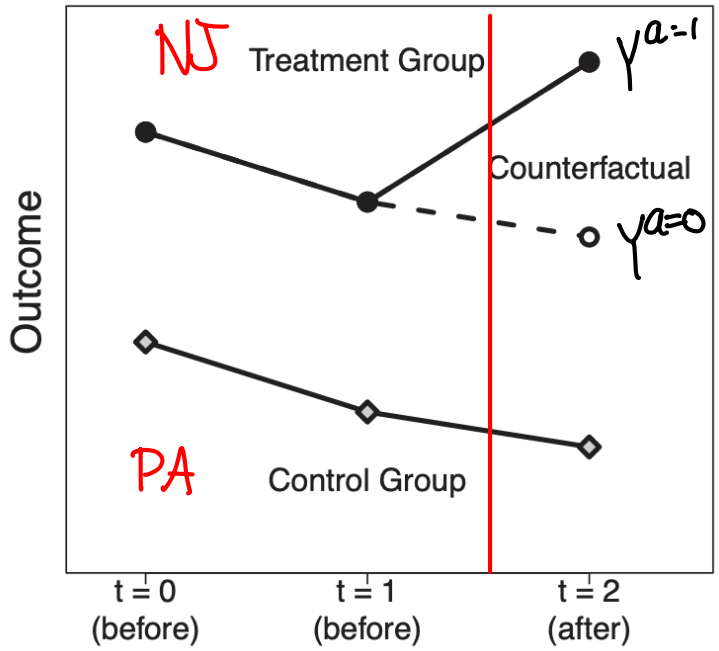
Learning goals for today

At the end of class, you will be able to:

1. Use pre-treatment periods to
   - assess underlying assumptions
   - improve estimation accuracy
   - allow for a more flexible parallel trends assumption
2. recognize that the parallel trends assumption remains untestable
3. and compare the differences between parallel trends, *extended* parallel trends, and parallel *trends-in-trends*

Egami, N., & Yamauchi, S. (2023).Using multiple pretreatment periods to improve difference-in-differences and staggered adoption designs.Political Analysis, 31(2), 195-212.

PollEv: Parallel Trends Review $ATT = E(Y^{a=1} \mid \text{Treatment Group}) - E(Y^{a=0} \mid \text{Treatment Group})$



Parallel trends is...
(select all that apply)

✓ 1. an assumption in the post-treatment period

✓ 2. an assumption about the treatment group

✓ 3. an assumption about a counterfactual

✓ 4. untestable

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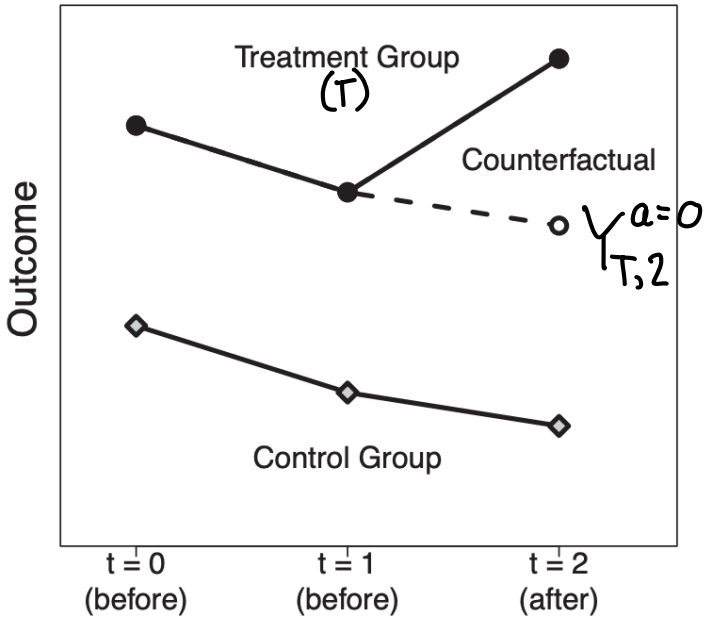
Difference in difference



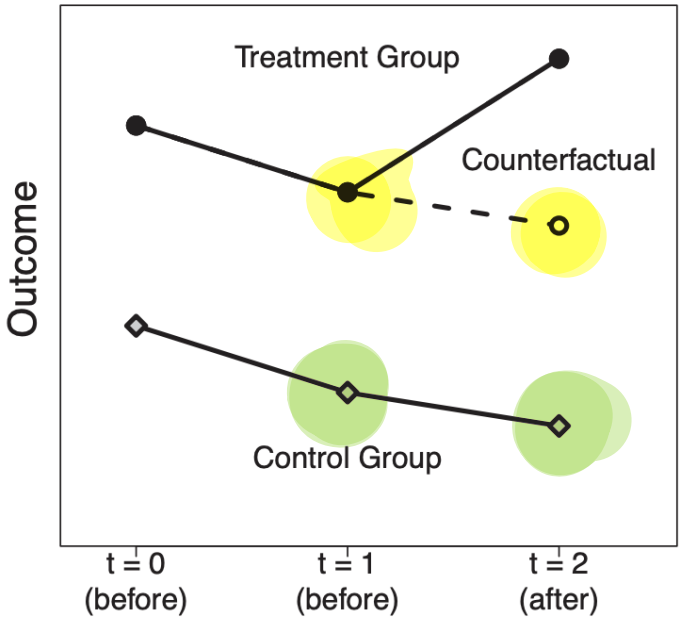
Notation

$Y^{\text{treatment value}}_{(\text{group}),(\text{time})}$

$Y^{a}_{i,t}$

Example: $Y^{0}_{Treated,1}$
is outcome of treated group
at time 1 under treatment 0

Difference in difference



Notation

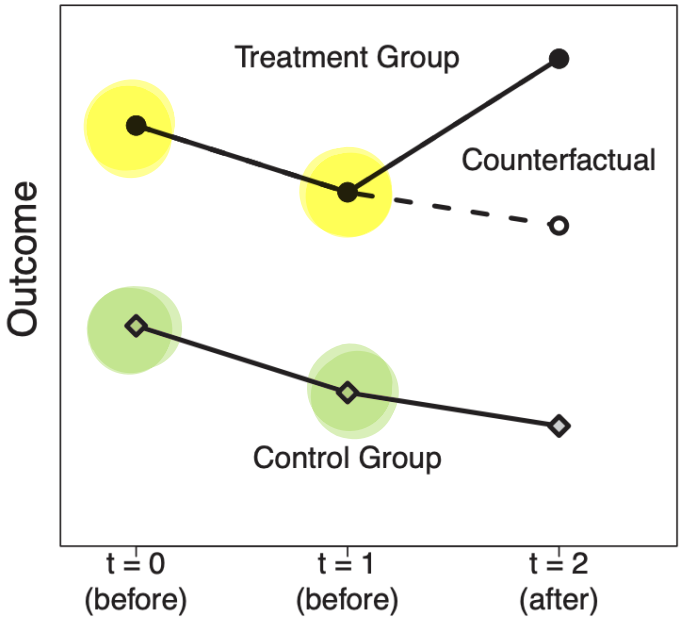
$$Y^{\text{treatment value}}_{\text{(group),(time)}}$$

Example: $Y^0_{Treated,1}$
is outcome of treated group
at time 1 under treatment 0

Parallel Trends Assumption (untestable)

$$E(Y^0_{\text{Treated},2} - Y^0_{\text{Treated},1}) = E(Y^0_{\text{Control},2} - Y^0_{\text{Control},1})$$

Difference in difference



counterfactual outcome

Parallel Trends Assumption
(untestable) post-treatment

$$E(Y^0_{\text{Treated},2} - Y^0_{\text{Treated},1}) = E(Y^0_{\text{Control},2} - Y^0_{\text{Control},1})$$

observed outcomes

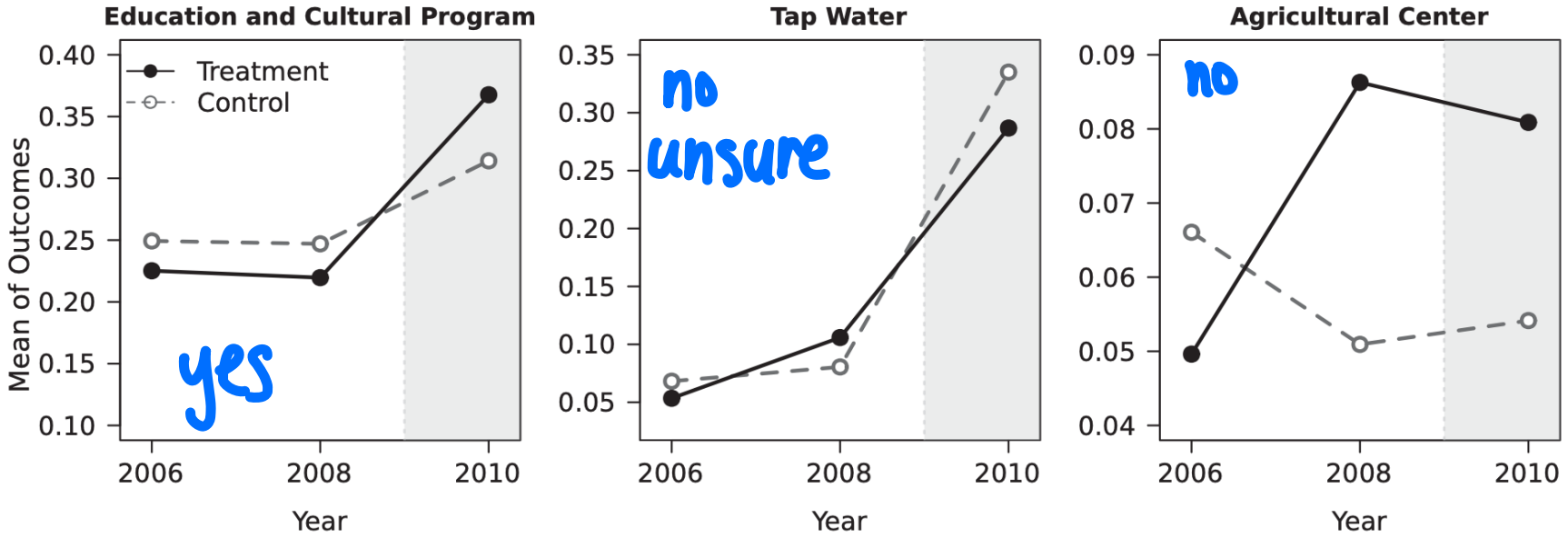
Extended Parallel Trends
(testable) pre-treatment

$$E(Y^0_{\text{Treated},1} - Y^0_{\text{Treated},0}) = E(Y^0_{\text{Control},1} - Y^0_{\text{Control},0})$$

Notation

$$Y^{\text{treatment value}}_{(\text{group}),(\text{time})}$$

Example: $Y^0_{Treated,1}$
is outcome of treated group
at time 1 under treatment 0



extended parallel trends
pre-treatment (observed outcomes)
testable

In each case, do you believe parallel trends?

post-treatment
untestable (because of counterfactual)

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Benefit 1: Assessing assumptions

Pre-treatment periods enable us to
assess underlying assumptions

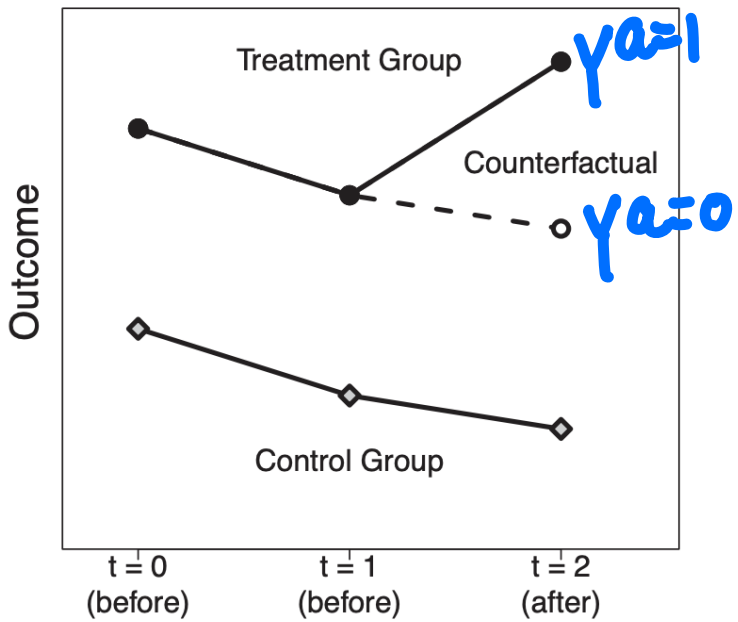
Parallel trends is untestable, but being parallel in the pre-treatment period builds confidence (not definitive proof)

called "extended parallel trends"

Benefit 2: Improving efficiency

Pre-treatment periods also enable us to
improve estimation accuracy
when parallel trends holds

Benefit 2: Improving efficiency



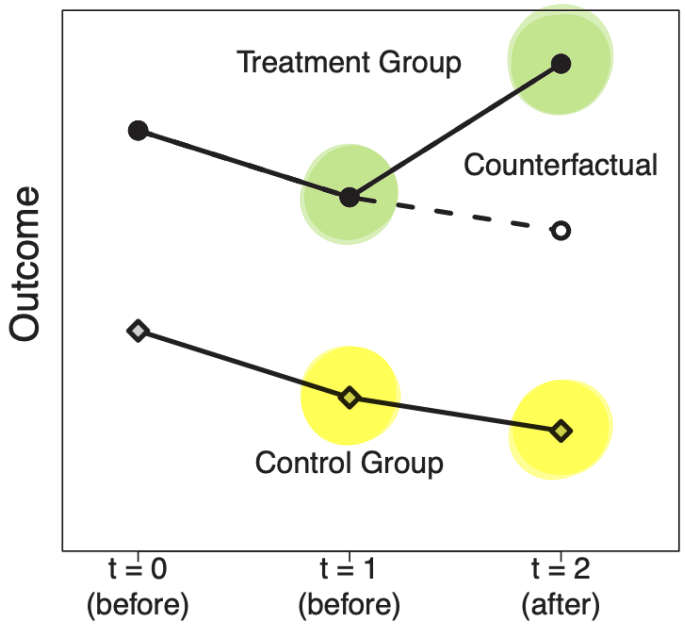
Estimator 1

Estimator 2

Notation

$Y^{\text{treatment value}}_{\text{(unit)(time)}}$

Benefit 2: Improving efficiency $E(Y^a) \approx \bar{Y}^a$



Estimator 1

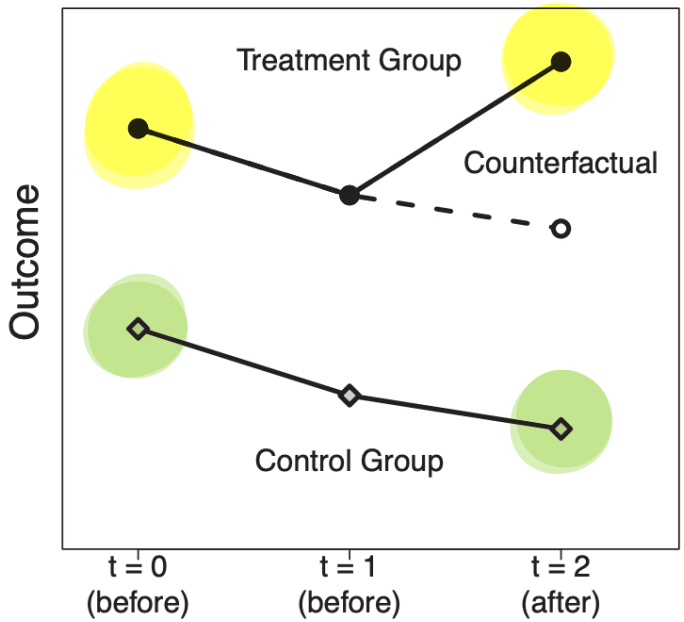
$$\underbrace{(\bar{Y}^1_{T2} - \bar{Y}^0_{T1})}_{\text{Treatment Group Time 2 - Time 1}} - \underbrace{(\bar{Y}^0_{C2} - \bar{Y}^0_{C1})}_{\text{Control Group Time 2 - Time 1}}$$

Estimator 2

Notation

$Y^{\text{treatment value}}_{(\text{unit})(\text{time})}$

Benefit 2: Improving efficiency



Estimator 1

$$\underbrace{(\bar{Y}^1_{T2} - \bar{Y}^0_{T1})}_{\substack{\text{Treatment Group} \\ \text{Time 2 - Time 1}}} - \underbrace{(\bar{Y}^0_{C2} - \bar{Y}^0_{C1})}_{\substack{\text{Control Group} \\ \text{Time 2 - Time 1}}}$$

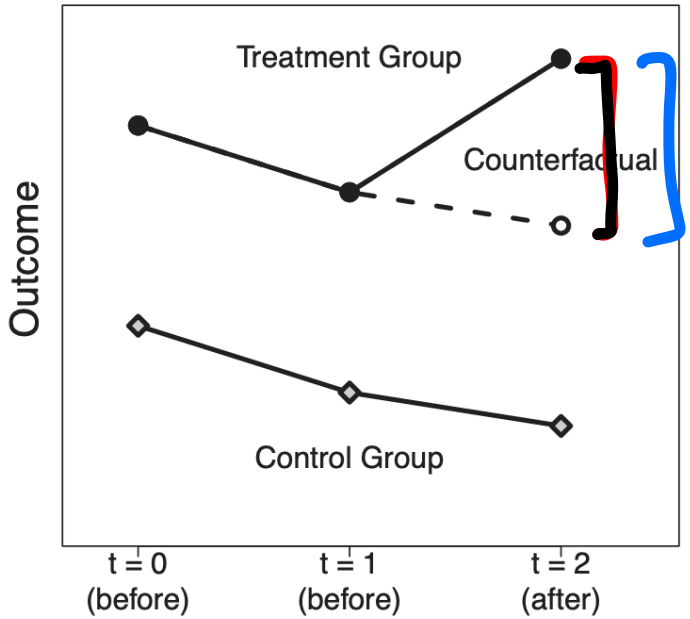
Estimator 2

$$\underbrace{(\bar{Y}^1_{T2} - \bar{Y}^0_{T0})}_{\substack{\text{Treatment Group} \\ \text{Time 2 - Time 0}}} - \underbrace{(\bar{Y}^0_{C2} - \bar{Y}^0_{C0})}_{\substack{\text{Control Group} \\ \text{Time 2 - Time 0}}}$$

Notation

$$Y^{\text{treatment value}}_{\text{(unit)(time)}}$$

Benefit 2: Improving efficiency



Estimator 1

$$\underbrace{(\bar{Y}^1_{T2} - \bar{Y}^0_{T1})}_{\substack{\text{Treatment Group} \\ \text{Time 2 - Time 1}}} - \underbrace{(\bar{Y}^0_{C2} - \bar{Y}^0_{C1})}_{\substack{\text{Control Group} \\ \text{Time 2 - Time 1}}}$$

Estimator 2

$$\underbrace{(\bar{Y}^1_{T2} - \bar{Y}^0_{T0})}_{\substack{\text{Treatment Group} \\ \text{Time 2 - Time 0}}} - \underbrace{(\bar{Y}^0_{C2} - \bar{Y}^0_{C0})}_{\substack{\text{Control Group} \\ \text{Time 2 - Time 0}}}$$

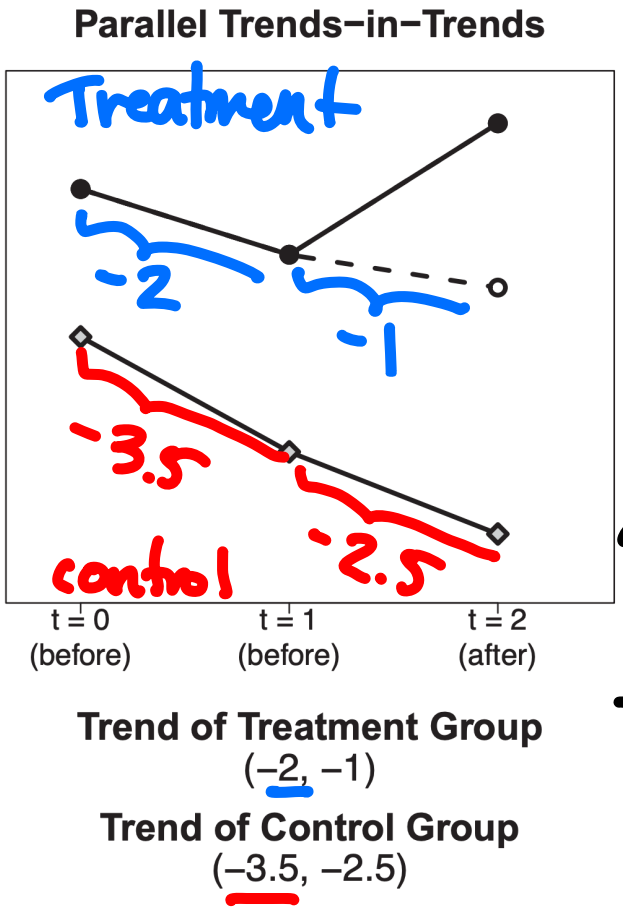
Notation

$$Y^{\text{treatment value}}_{\text{(unit)(time)}}$$

Double DID Estimator: Average the two!

Benefit 3: A more flexible assumption

Pre-treatment periods make it possible to
allow for a more flexible parallel trends assumption



↑ -2+1 = -1

↑1

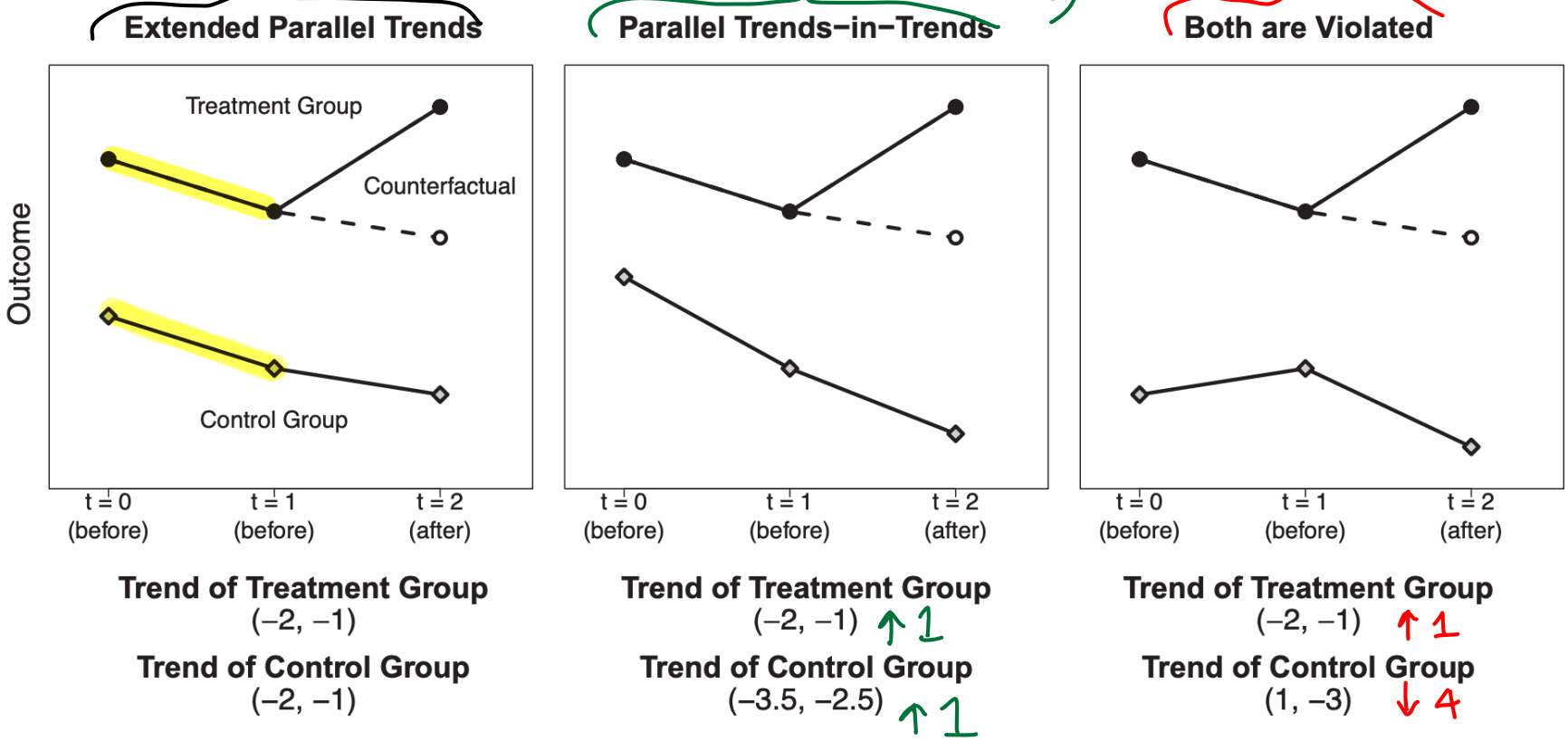
-3.5+1 = -2.5

Benefit 3: A more flexible assumption

Trends in pre-treatment period are parallel (testable)

trends are not parallel but the way the slopes change is the same (untestable)

trends are not parallel pre-treatment & even the way the slopes change are different



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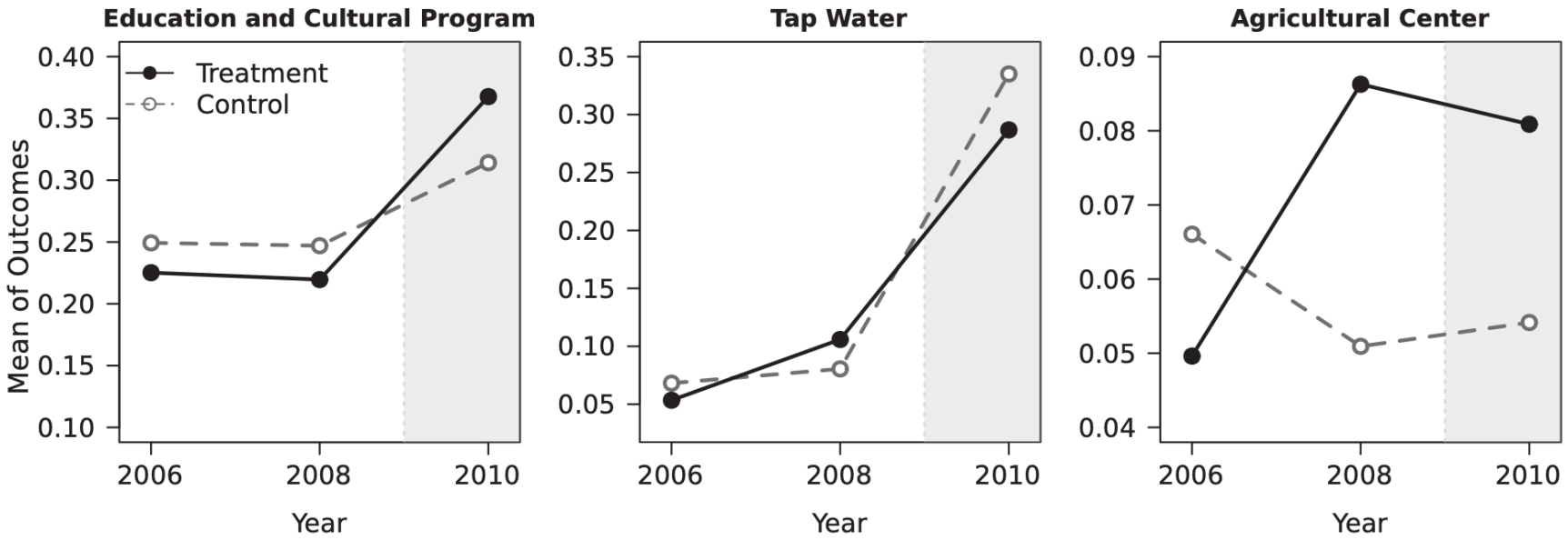
(recap) Main DiD assumption: parallel trends

Benefits of multiple pre-treatment periods

1. assess underlying assumptions
2. improve estimation accuracy
3. allow for a more flexible parallel trends assumption



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