Difference in difference

STSCI/ INFO/ ILRST 3900: Causal Inference

17 Nov 2026

Learning goals for today

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

1. Study effects of policies using difference in differences when data is recorded before and after treatment is applied
2. Reason about the parallel trends assumption

Economic theory

When the minimum wage rises, how might employment at fast food restaurants change?

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Card, D., & Krueger, A. B. (1994).
Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania.
The American Economic Review, 84(4), 772-793.

The setting

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- Federal minimum wage
  - $3.80 on April 1, 1990
  - $4.25 on April 1, 1991

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- New Jersey minimum wage
  - \$5.05 on April 1, 1992
- We want to compare NJ in May (after change) to potential outcome of NJ in May in hypothetical world without change
- We could instead compare NJ in March vs NJ in May
- Assumes (untreated) NJ would not have changed from March to May
- Can we estimate how (untreated) NJ might have changed from March to May?

Economic theory

When the minimum wage rises, how might employment at fast food restaurants change?

- What evidence would be convincing to you?
- How would you design an experiment to test?



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BURGER
KING

KFC

Roy
Rogers

Wendy's



171 stores



80 stores



99 stores



60 stores



171 stores



80 stores



99 stores



60 stores

Phone interview: Feb-Mar 1992 before minimum wage rose
364 in NJ and 109 in PA

Nov-Dec 1992 after minimum wage rose
331 in NJ and 79 in PA



171 stores



80 stores



99 stores



60 stores

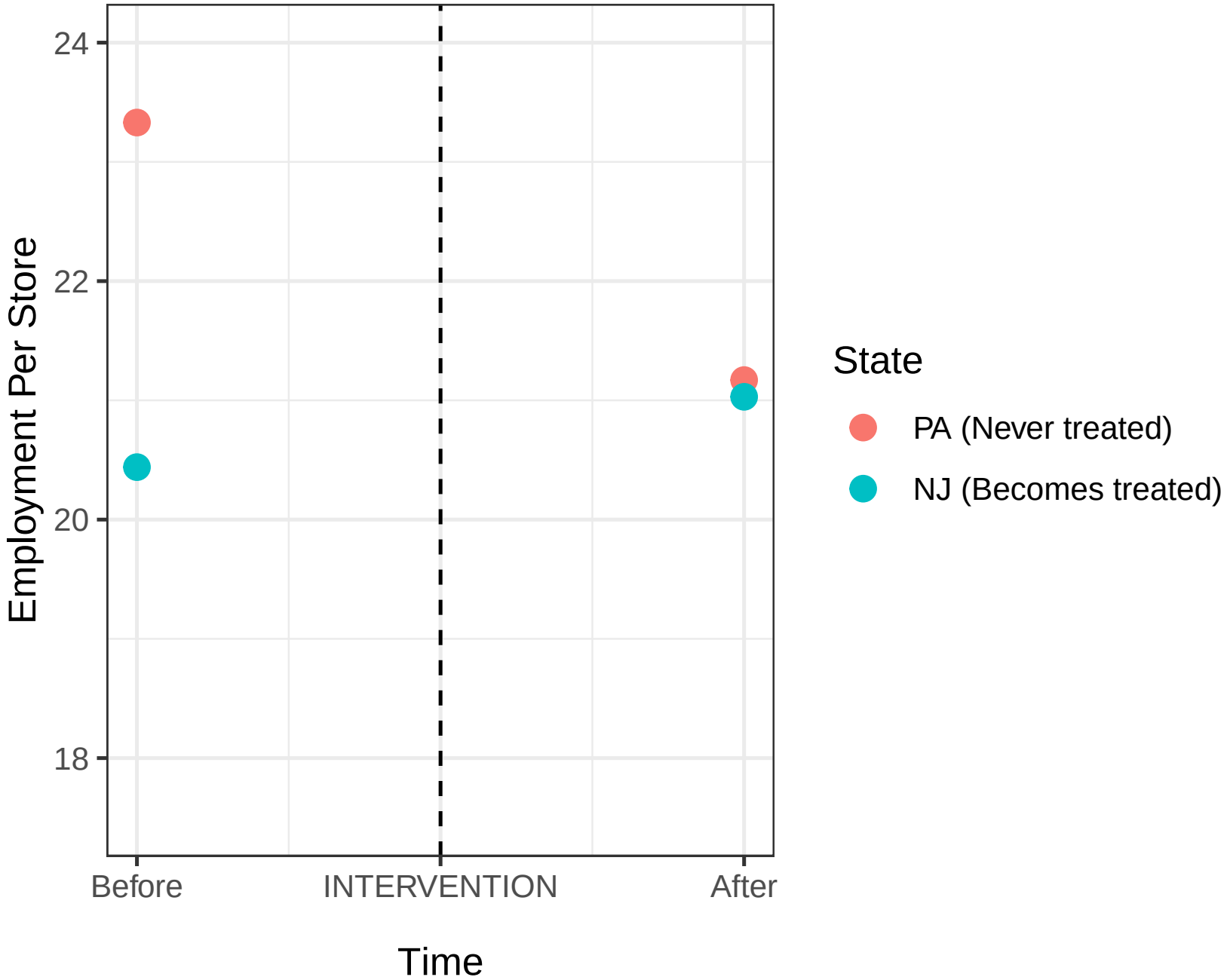
Phone interview: Feb-Mar 1992 before minimum wage rose
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Nov-Dec 1992 after minimum wage rose
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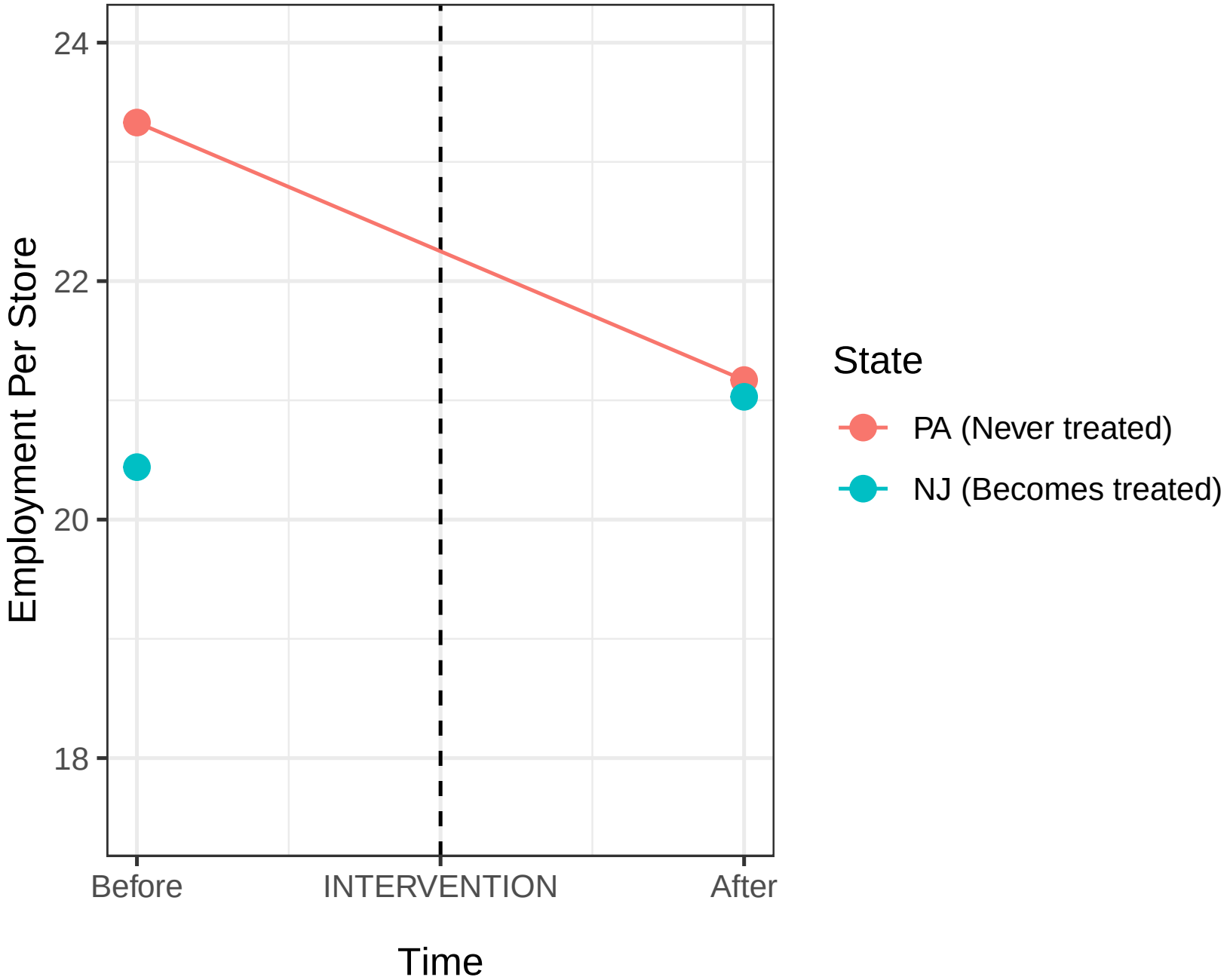
Recorded: How many full-time equivalent employees?

Variable	Stores by state		
	PA (i)	NJ (ii)	Difference, NJ − PA (iii)
1. FTE employment before, all available observations	23.33 (1.35)	20.44 (0.51)	−2.89 (1.44)
2. FTE employment after, all available observations	21.17 (0.94)	21.03 (0.52)	−0.14 (1.07)
3. Change in mean FTE employment	−2.16 (1.25)	0.59 (0.54)	2.76 (1.36)

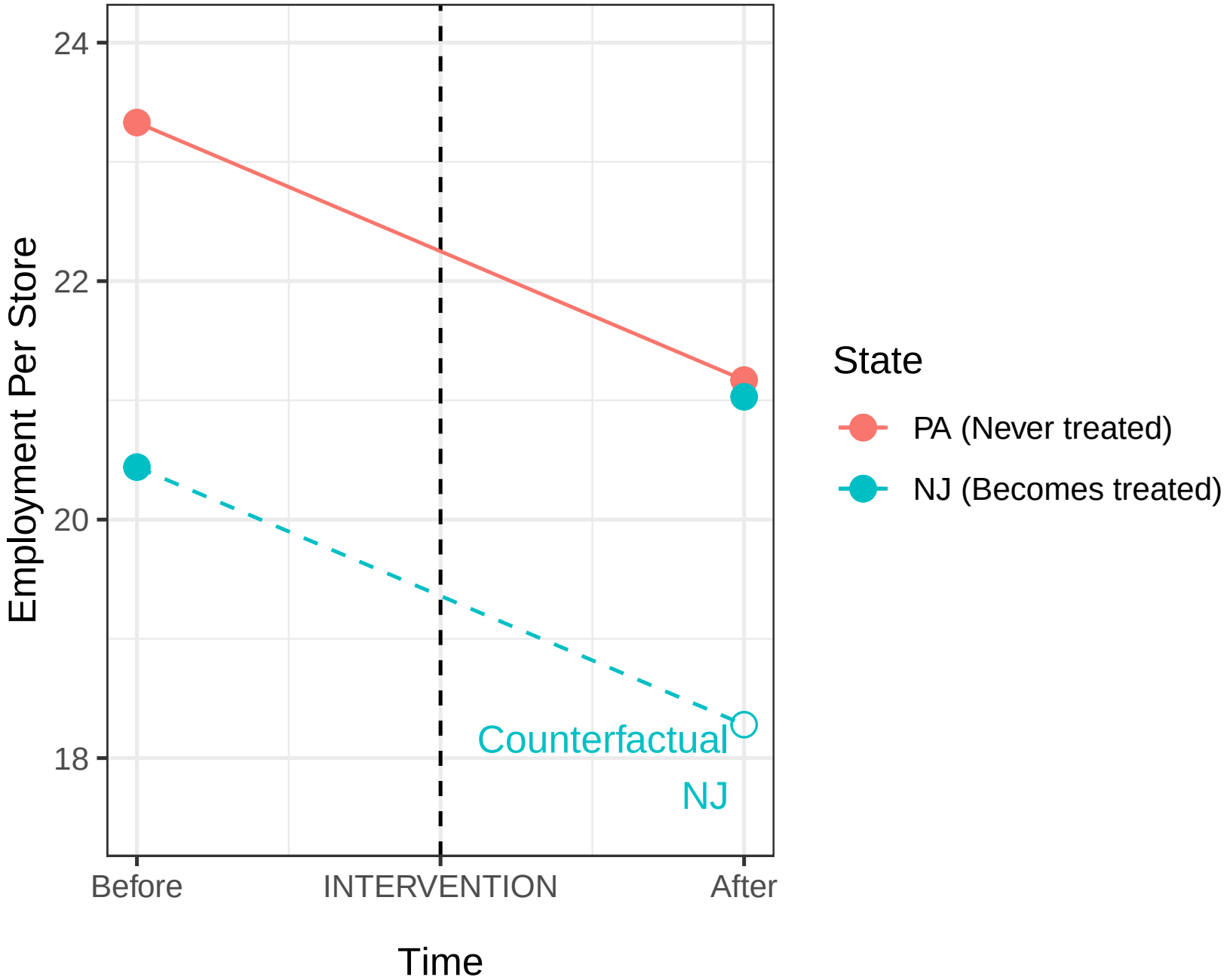
How did employment change?



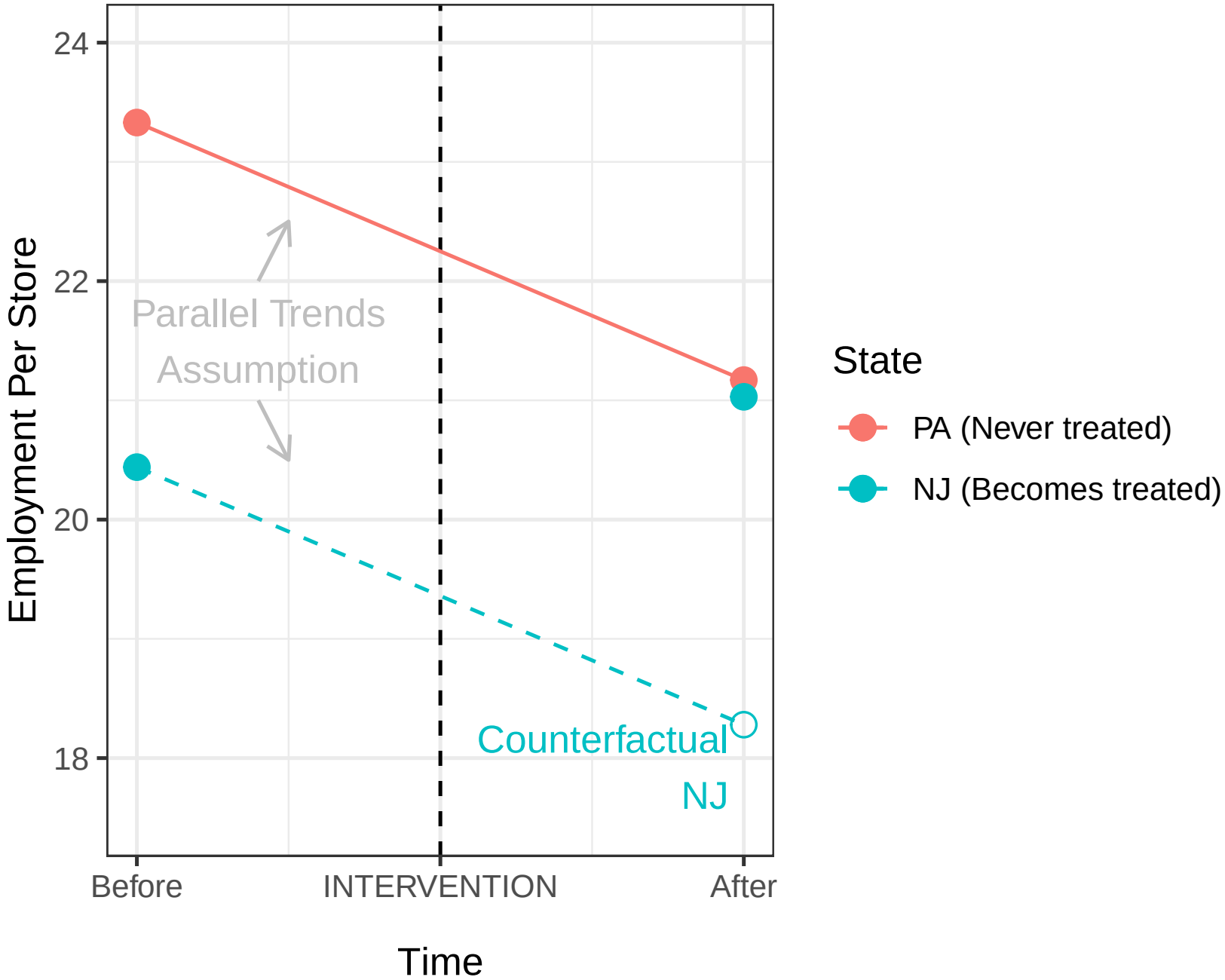
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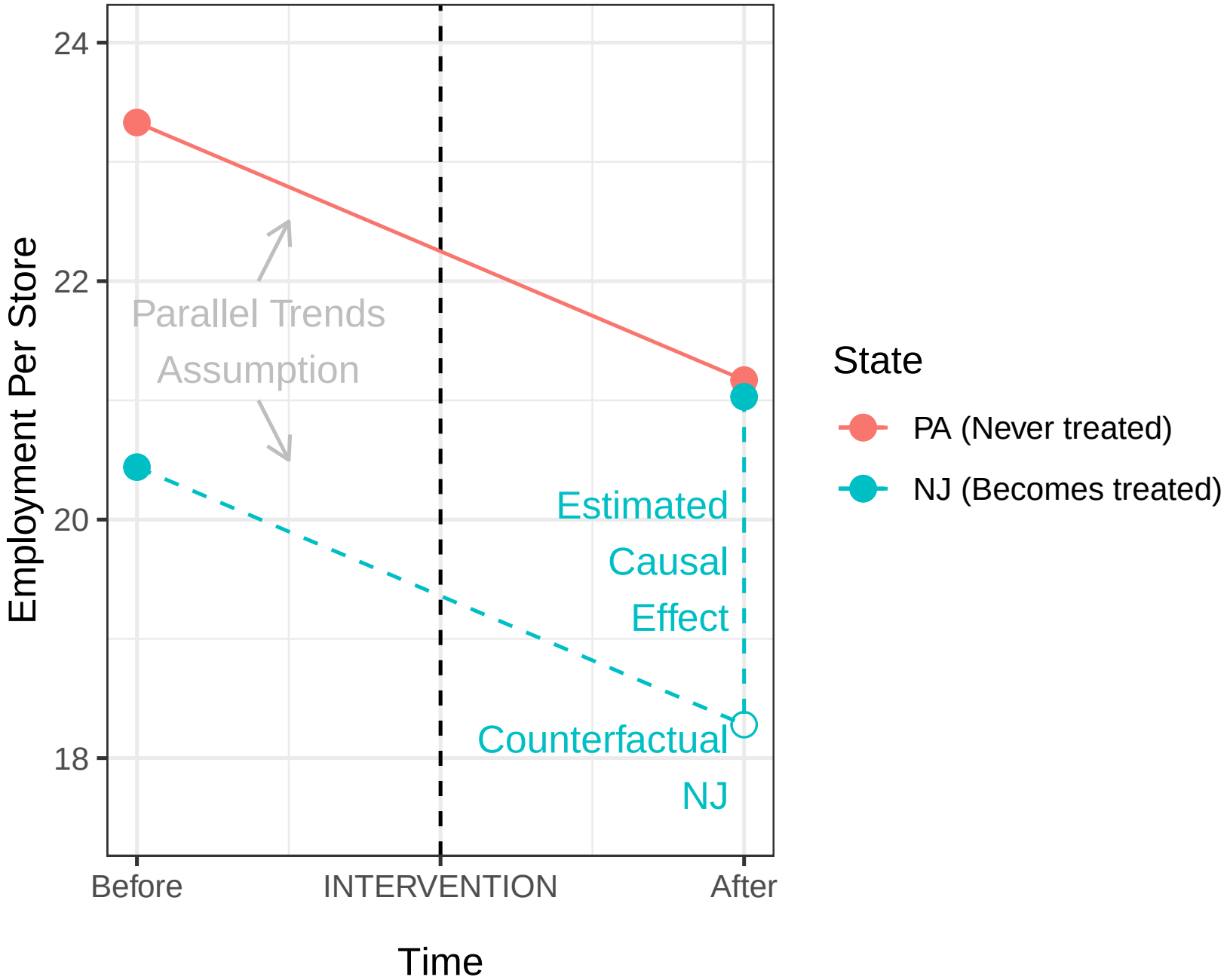
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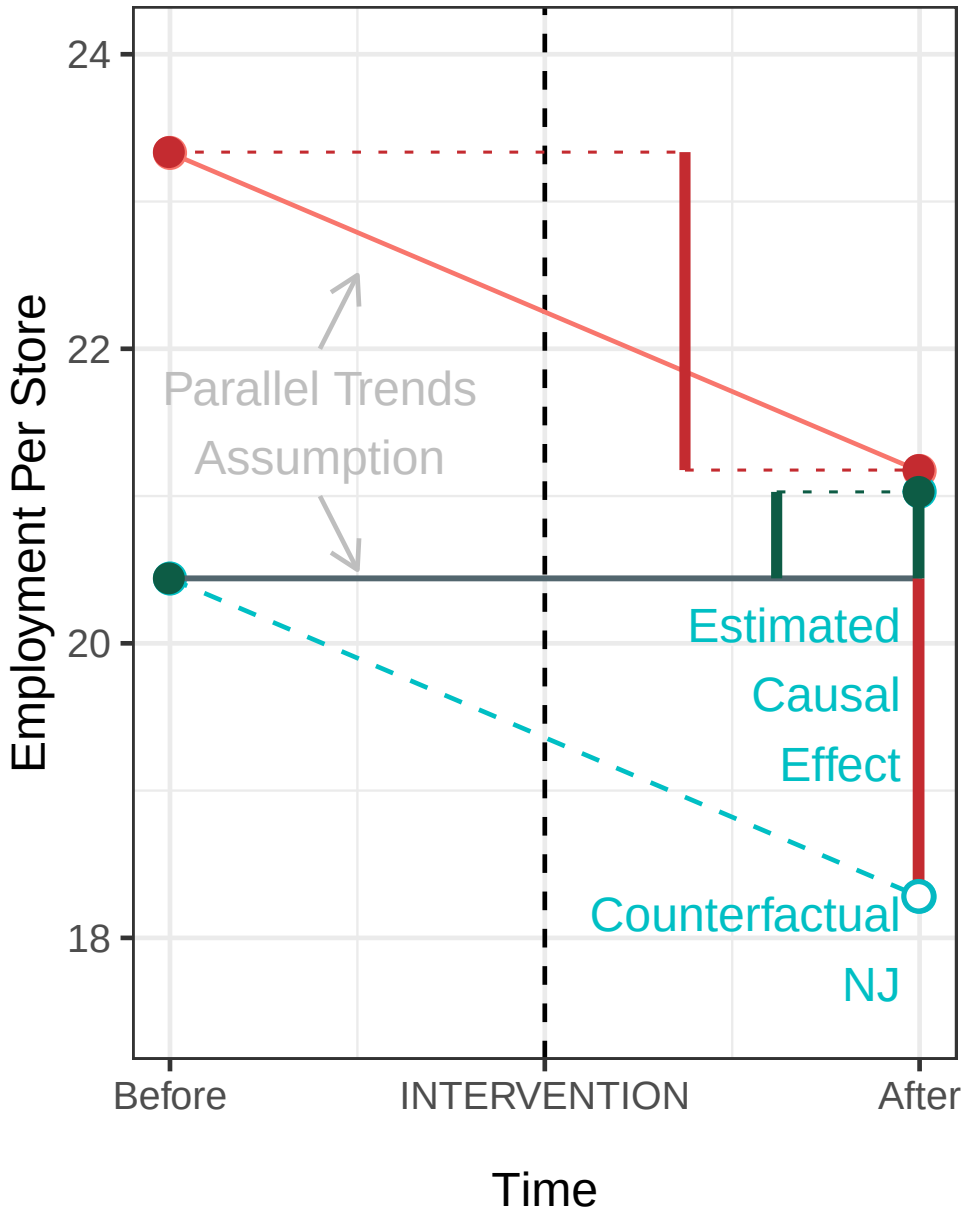
How did employment change?



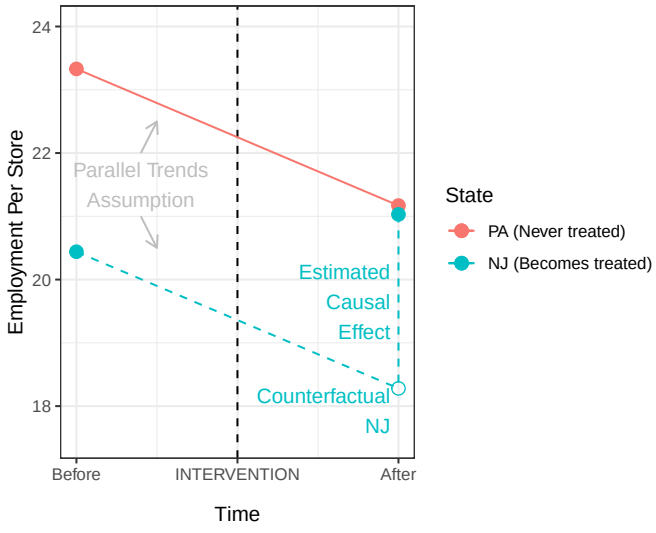
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How did employment change?



Difference in difference

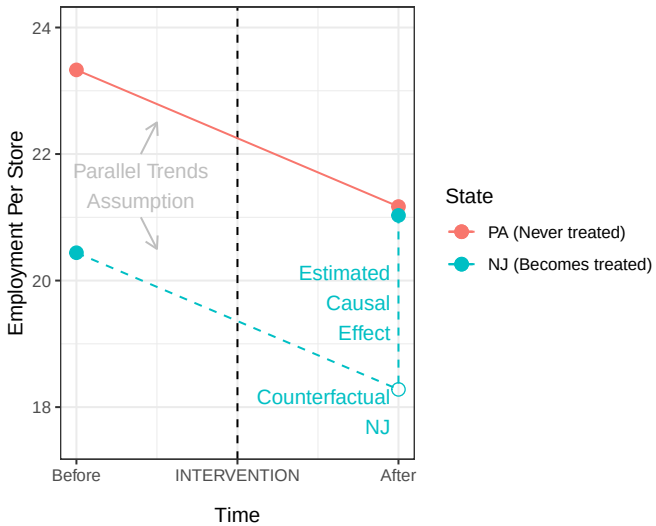


Notation

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

Example: Y^0_{i1}
is unit i at time 1
under treatment 0

Difference in difference



Notation

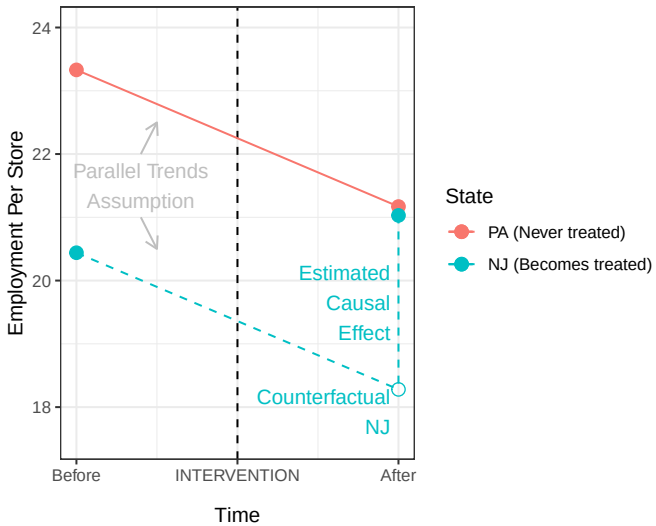
$$Y^{\text{treatment value}}_{(\text{unit})(\text{time})}$$

Example: Y^0_{i1}
is unit i at time 1
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Parallel Trends Assumption (untestable)

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

Difference in difference



Parallel Trends Assumption (untestable)

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

- The assumption of parallel trends is about untreated NJ
- Assumption is untestable because of the fundamental problem of causal inference: we only observe Treated NJ
- More data can help us decide whether its reasonable or not

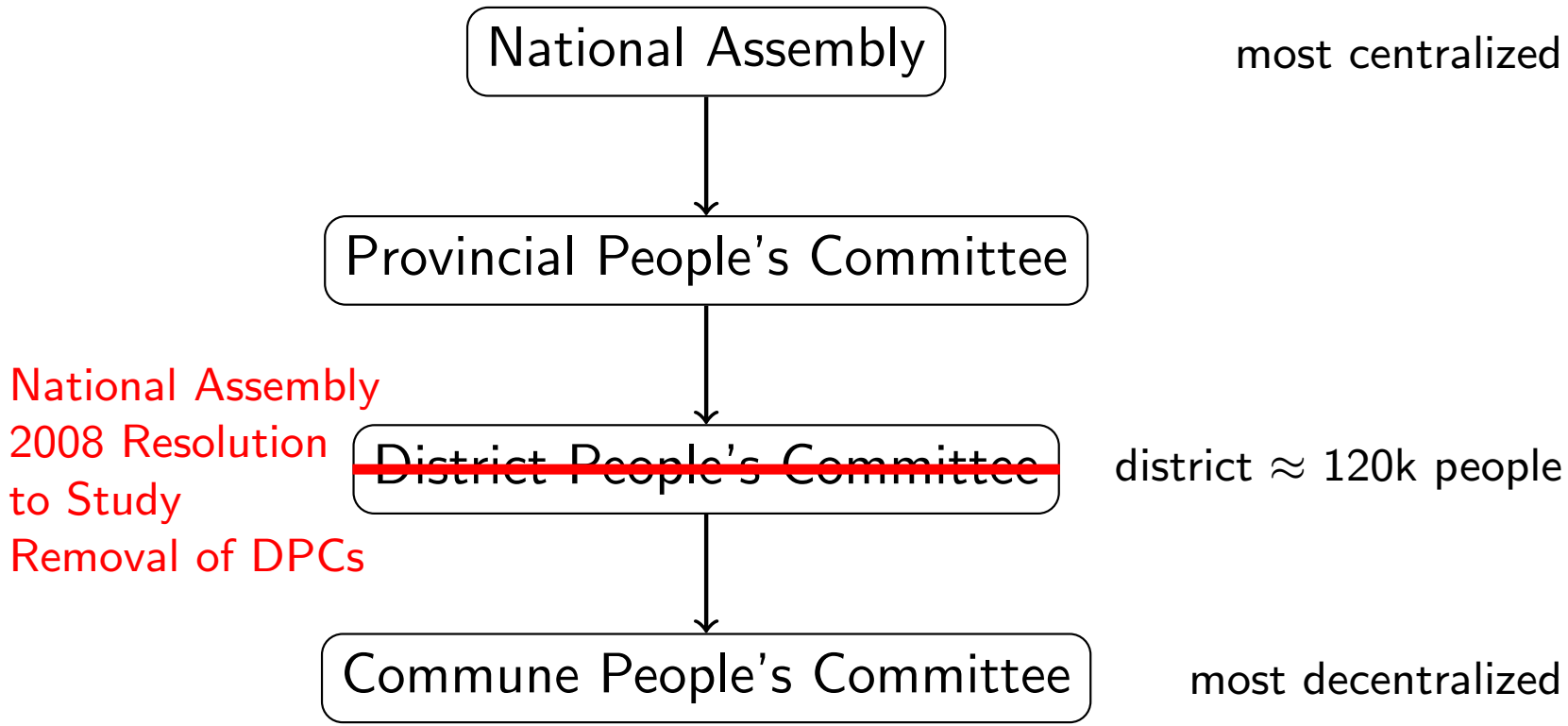
Extended Parallel Trends

Malesky, E. J., Nguyen, C. V., & Tran, A. (2014).
The impact of recentralization on public services:
A difference-in-differences analysis of the abolition of elected councils in Vietnam.
American Political Science Review, 108(1), 144-168.

Egami N, Yamauchi S. Using Multiple Pretreatment Periods to Improve Difference-in-Differences and Staggered Adoption Designs.
Political Analysis. 2023;31(2):195-212.

Does government work better when it is centralized or decentralized?

Vietnam setting: A study of recentralization

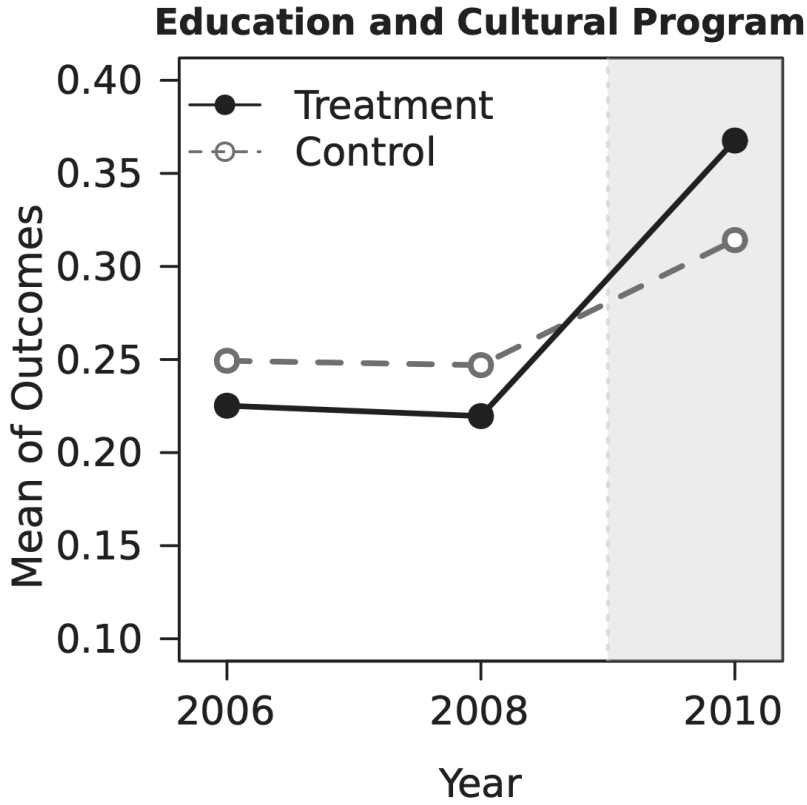


Vietnam Household Living Standards Survey
Reports by each local commune by commune leaders

- 2006 and 2008: Before DPC abolition
- 2010: After DPC abolition

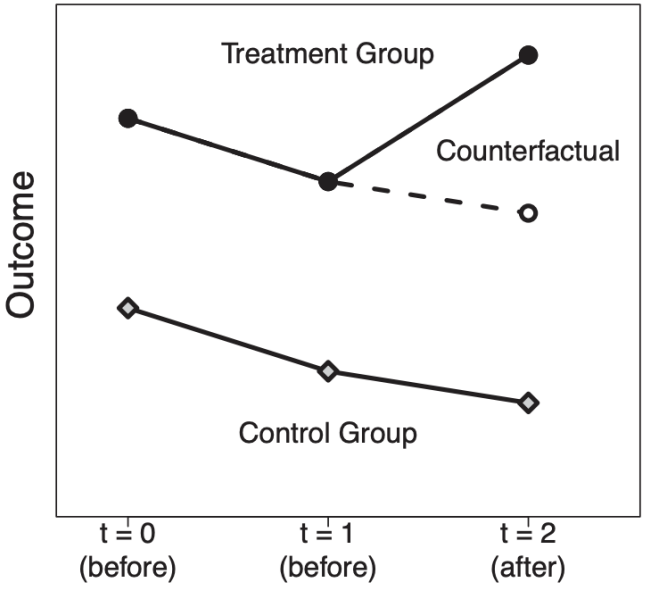
One outcome we will examine:
Is there the following project in the commune?

- Investment on culture and education
- Availability of tap water
- Existence of agricultural center



Screenshot of re-analysis by Egami & Yamauchi 2023, Fig 3

Extended parallel trends



Notation

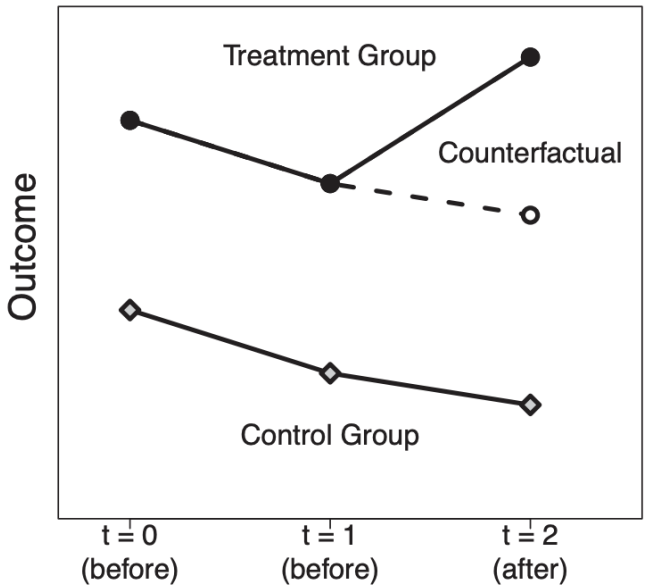
$$Y^{\text{treatment value}}_{\text{(unit)(time)}}$$

Example: Y^0_{i1}
is unit i at time 1
under treatment 0

Parallel Trends Assumption (untestable)

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

Extended parallel trends



Notation

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

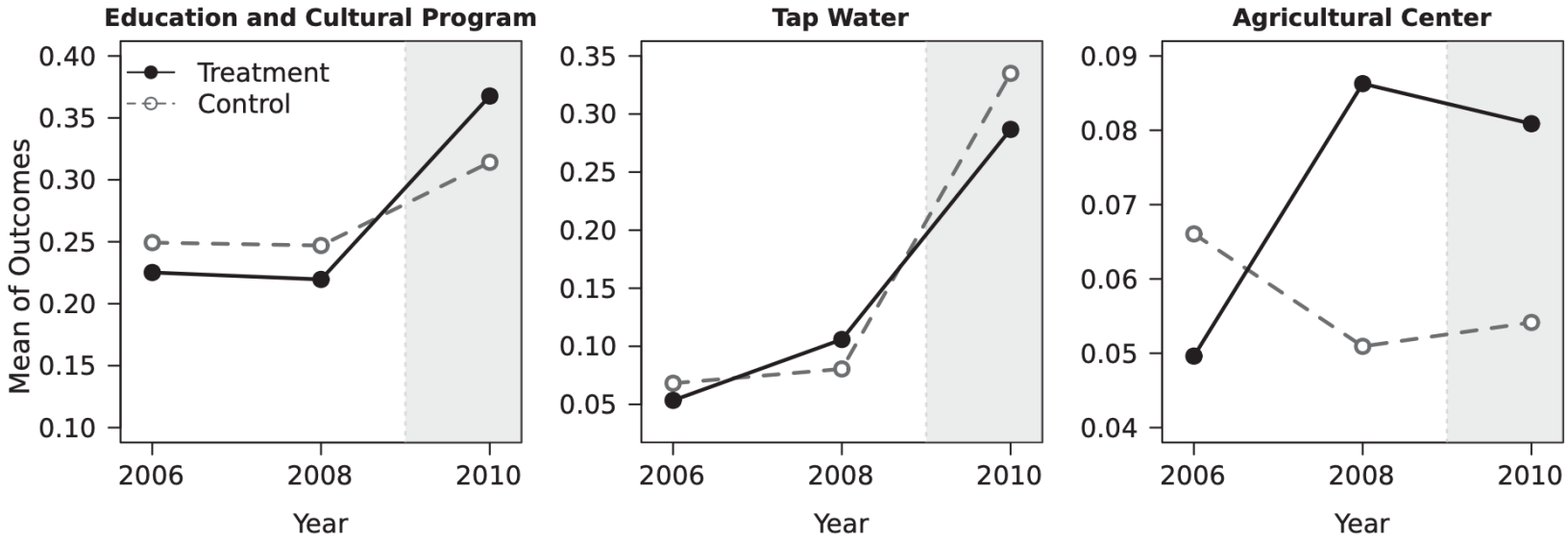
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Extended Parallel Trends (testable)

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



In each case, do you believe parallel trends?

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