

Differences in Differences

Econ 140, Section 10

Jonathan Old

1. Motivation



Any questions?

... Remember – Every question is useful!

Motivation

Motivation

- In the first part of the course, we talked about comparison between groups: Treatment vs. Control
- Last week, we talked about comparisons over time: Time series
- Both of these have very big and obvious problems, but we can use them **together** in a powerful tool: Differences-in-differences!

How to get the causal effect of a treatment

In 2021, UC Berkeley offered free mental health coachings to students with pre-existing mental health issues. We want to evaluate the effect of this policy and we collect a depression score (0-10) for all students at UC Berkeley.

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated	4	5

We can do several comparisons:

How to get the causal effect of a treatment II

	2020	2022
Free Mental Health: Treated		6
No Free Mental Health: Untreated		

We can do several comparisons:

- Comparison 1: Just look at the treatment group outcome (6)

How to get the causal effect of a treatment II

	2020	2022
Free Mental Health: Treated		6
No Free Mental Health: Untreated		

We can do several comparisons:

- Comparison 1: Just look at the treatment group outcome (6)
- Problem: We learn nothing!

How to get the causal effect of a treatment III

	2020	2022
Free Mental Health: Treated		6
No Free Mental Health: Untreated		5

We can do several comparisons:

- Comparison 2: Compare treated and non-treated group after the intervention

How to get the causal effect of a treatment III

	2020	2022
Free Mental Health: Treated		6
No Free Mental Health: Untreated		5

We can do several comparisons:

- Comparison 2: Compare treated and non-treated group after the intervention
- Estimated treatment effect? $6 - 5 = 1$

How to get the causal effect of a treatment III

	2020	2022
Free Mental Health: Treated		6
No Free Mental Health: Untreated		5

We can do several comparisons:

- Comparison 2: Compare treated and non-treated group after the intervention
- Estimated treatment effect? $6 - 5 = 1$
- Problems?

How to get the causal effect of a treatment III

	2020	2022
Free Mental Health: Treated		6
No Free Mental Health: Untreated		5

We can do several comparisons:

- Comparison 2: Compare treated and non-treated group after the intervention
- Estimated treatment effect? $6 - 5 = 1$
- Problems?
- Identifying assumption: The average difference between groups is due to the treatment only. Without the treatment, the average outcome of the treated group would have been equal to the average outcome of the control group.

How to get the causal effect of a treatment IV

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated		

We can do several comparisons:

- Comparison 3: Compare treated group before and after the intervention

How to get the causal effect of a treatment IV

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated		

We can do several comparisons:

- Comparison 3: Compare treated group before and after the intervention
- Estimated treatment effect? $6 - 6 = 0$

How to get the causal effect of a treatment IV

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated		

We can do several comparisons:

- Comparison 3: Compare treated group before and after the intervention
- Estimated treatment effect? $6 - 6 = 0$
- Problems?

How to get the causal effect of a treatment IV

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated		

We can do several comparisons:

- Comparison 3: Compare treated group before and after the intervention
- Estimated treatment effect? $6 - 6 = 0$
- Problems?
- Identifying assumption: The average difference across time is due to the treatment only. Without the treatment, the average outcome of the treated group would not have changed.

How to get the causal effect of a treatment: DiD

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated	4	5

We can do several comparisons:

- Comparison 4: Compare treated to untreated group, before and after the intervention. **Differences in differences!**

How to get the causal effect of a treatment: DiD

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated	4	5

We can do several comparisons:

- Comparison 4: Compare treated to untreated group, before and after the intervention. **Differences in differences!**
- Estimated treatment effect?

$$(6 - 6) - (5 - 4) = (6 - 5) - (6 - 4) = -1$$

How to get the causal effect of a treatment: DiD

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated	4	5

We can do several comparisons:

- Comparison 4: Compare treated to untreated group, before and after the intervention. **Differences in differences!**
- Estimated treatment effect?
 $(6 - 6) - (5 - 4) = (6 - 5) - (6 - 4) = -1$
- Identifying assumption: Parallel trends: Without the treatment, the average increase in the outcome of the treated would have been the same as the average increase in the outcome of the untreated.

Sidenote

... We can NOT observe the identifying assumption! We can find evidence for or against it, but we can never be sure!

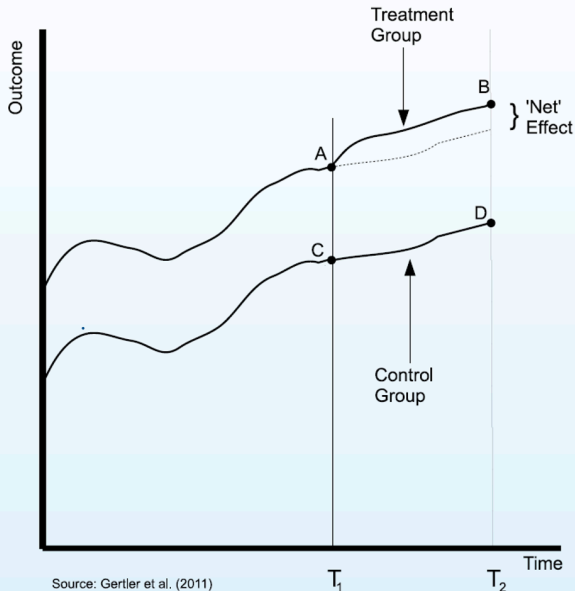
How to get the causal effect of a treatment: DiD

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated	4	5

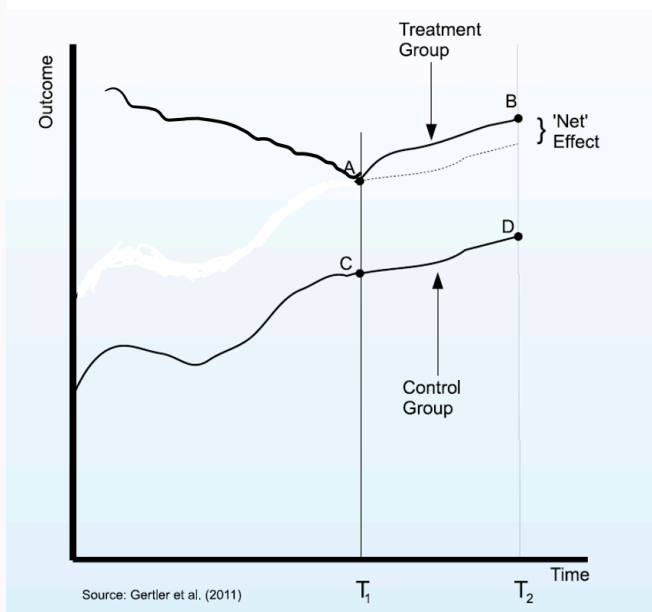
We can calculate the DiD estimate in two ways:

$$\begin{aligned} DD &= E[\underbrace{(Y_{i1}^T - Y_{i0}^T)}_{\text{Gain over time for treated}} - \underbrace{(Y_{i1}^C - Y_{i0}^C)}_{\text{Gain over time for untreated}}] \\ &= E[\underbrace{(Y_{i1}^T - Y_{i1}^C)}_{\text{Post-treatment diff treated}} - \underbrace{(Y_{i0}^T - Y_{i0}^C)}_{\text{Pre-treatment diff}}] \end{aligned}$$

Parallel trends assumption



Parallel trends assumption II



Estimating DiD with regressions

We can set up a simple linear regression model to get the DiD estimate:

$$Y_{it} = \alpha + \beta \text{Treated}_i + \gamma \text{Post}_t + \delta \text{Treated}_i \cdot \text{Post}_t + u_{it}$$

	2020	2022
Free Mental Health: Treated	$\alpha + \beta$	$\alpha + \beta + \gamma + \delta$
No Free Mental Health: Untreated	α	$\alpha + \gamma$

Estimating DiD with regressions

We can set up a simple linear regression model to get the DiD estimate:

$$Y_{it} = \alpha + \beta \text{Treated}_i + \gamma \text{Post}_t + \delta \text{Treated}_i \cdot \text{Post}_t + u_{it}$$

	2020	2022
Free Mental Health: Treated	6	6
No Free Mental Health: Untreated	4	5

With our data, we would get:

- $\alpha = 4$
- $\beta = 2$
- $\gamma = 1$
- $\delta = -1$

Any questions?

... Remember – Every question is useful!