

ECMA31100 Introduction to Empirical Analysis II

Winter 2022, Week 8, Part 2: Discussion Session

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Part 2 of Week 8

Topics for this week's TA session

- Due to popular request, I will focus on the following two topics:
 - Treatment choice —→ See part 1 of the week 8 slides
 - Difference-in-differences/event study

Part 2: Difference-in-differences and event study

- Focus on Callaway and Sant'Anna (2021)

Contents

1. Difference-in-differences

2. Event study

Difference-in-differences

Set-up

- Two periods: $t \in \{1, 2\}$
- Binary treatment: $D_{it} \in \{0, 1\}$
- Outcome variables: Y_{it}^1, Y_{it}^0
- Observed outcome in period t : $Y_{it} = D_{it}(Y_{it}^1 - Y_{it}^0) + Y_{it}^0$

	Treatment	Control
Before	Y_{i1}^0	Y_{i1}^0
After	Y_{i2}^1	Y_{i2}^0

Difference-in-differences

Common trend

$$\mathbb{E}[Y_{i2}^0 - Y_{i1}^0 | D_{i2} = 1] = \mathbb{E}[Y_{i2}^0 - Y_{i1}^0 | D_{i2} = 0]$$

Average treatment effect on the treated

- First-difference (after-before of treatment group):

$$\mathbb{E}[Y_{i2} - Y_{i1} | D_{i2} = 1] = \mathbb{E}[Y_{i2}^1 - Y_{i2}^0 | D_{i2} = 1] + \mathbb{E}[Y_{i2}^0 - Y_{i1}^0 | D_{i2} = 1]$$

- Second-difference (after-before of control group):

$$\mathbb{E}[Y_{i2} - Y_{i1} | D_{i2} = 0] = \mathbb{E}[Y_{i2} - Y_{i1} | D_{i2} = 0]$$

- DiD identifies ATT as follows:

$$ATT = \mathbb{E}[Y_{i2}^1 - Y_{i2}^0 | D_{i2} = 1] = \mathbb{E}[Y_{i2} - Y_{i1} | D_{i2} = 1] - \mathbb{E}[Y_{i2} - Y_{i1} | D_{i2} = 0]$$

Difference-in-differences

DiD as regression

$$Y_{it} = \beta_0 + \beta_1 \text{treat}_i + \beta_2 \text{after}_t + \beta_3 \text{treat}_i \cdot \text{after}_t + \epsilon_{it}$$

	Treatment	Control	Differences
Before	$\beta_0 + \beta_1$	β_0	β_1
After	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\beta_0 + \beta_2$	$\beta_1 + \beta_3$
Differences	$\beta_2 + \beta_3$	β_2	β_3

Any questions?

Contents

1. Difference-in-differences

2. Event study

Event study

Set-up

- Multiple periods: $t \in \{1, 2, \dots, T\}$
- Binary treatment: $D_{it} \in \{0, 1\}$
- Outcome variables: Y_{it}^1, Y_{it}^0
- If $T = 2$, then we return to the set-up in the previous section

Absorbing date and event date

- Let E_i be the event date for unit i so that $D_{it} \equiv \mathbb{1}[t \geq E_i]$
- If i is never treated, then $E_i = \infty$

Callaway and Sant'Anna (2021)

DGP

- Number of units: 1,000
- Number of states: 40
- Time period: 1980 to 2010
- 4 groups: $g \in \{1986, 1992, 1998, 2004\}$
- Outcome:

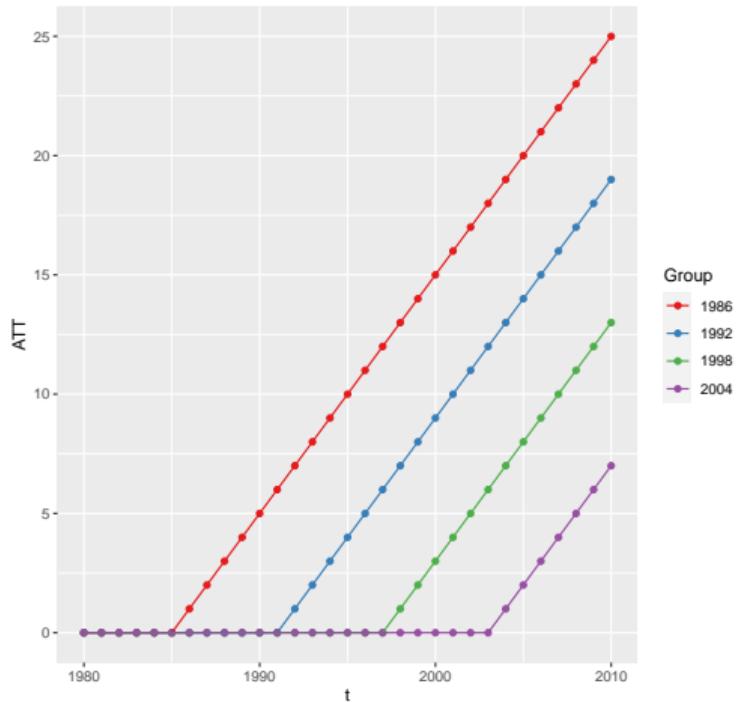
$$Y_{i,t} = \underbrace{2010 - g}_{\text{Cohort-specific intercept}} + \underbrace{\alpha_i}_{\mathcal{N}\left(\frac{\text{State}}{5}, 1\right)} + \underbrace{\alpha_t}_{\mathcal{N}(0, 1) + \frac{t-g}{10}} + \underbrace{\tau_{i,t}}_{(t-g+1)\mathbf{1}[t \geq g]} + \underbrace{\epsilon_{i,t}}_{\mathcal{N}(0, \frac{1}{4})}$$

ATT

- The ATT t periods after being treated is t (see figure 1)

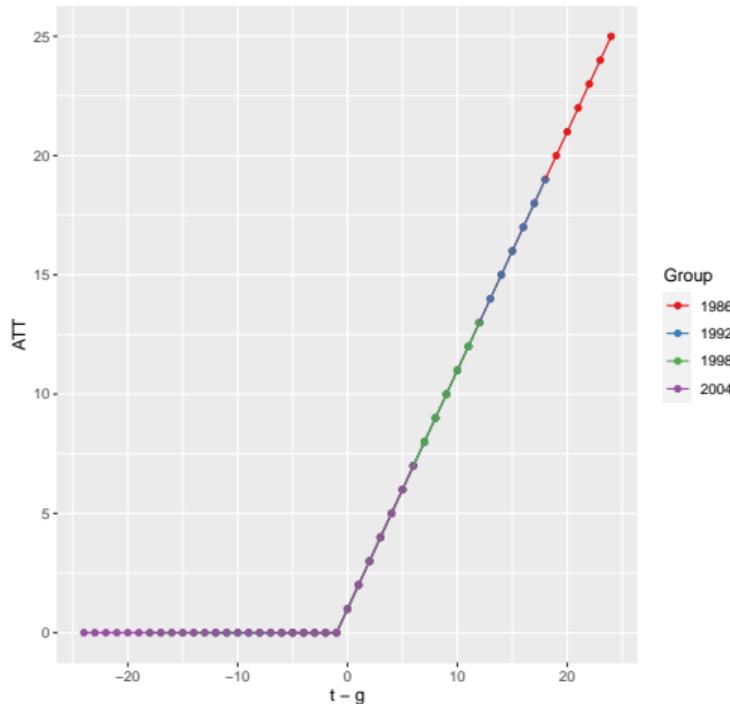
Callaway and Sant'Anna (2021)

Figure 1: ATT for each of the four groups



Callaway and Sant'Anna (2021)

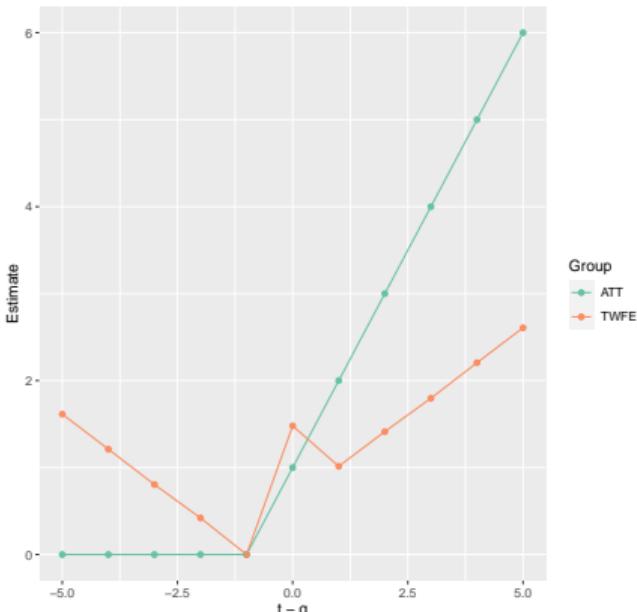
Figure 2: ATT in “event time”, i.e., $t - g$ (treatment effect are homogeneous here)



Callaway and Sant'Anna (2021)

Figure 3: Result from running the following TWFE

$$Y_{i,t} = \alpha_i + \alpha_t + \gamma_k^{-5} D_{i,t}^{<-5} + \sum_{k=-5}^{-2} \gamma_k^{\text{lead}} D_{it}^k + \sum_{k=0}^5 \gamma_k^{\text{lag}} D_{it}^k + \gamma_k^{+5} D_{i,t}^{>5} + \epsilon_{it}$$



Group-specific ATT

Under some identification assumptions, we may identify ATT as follows:

- Use never-treated (nev) groups:

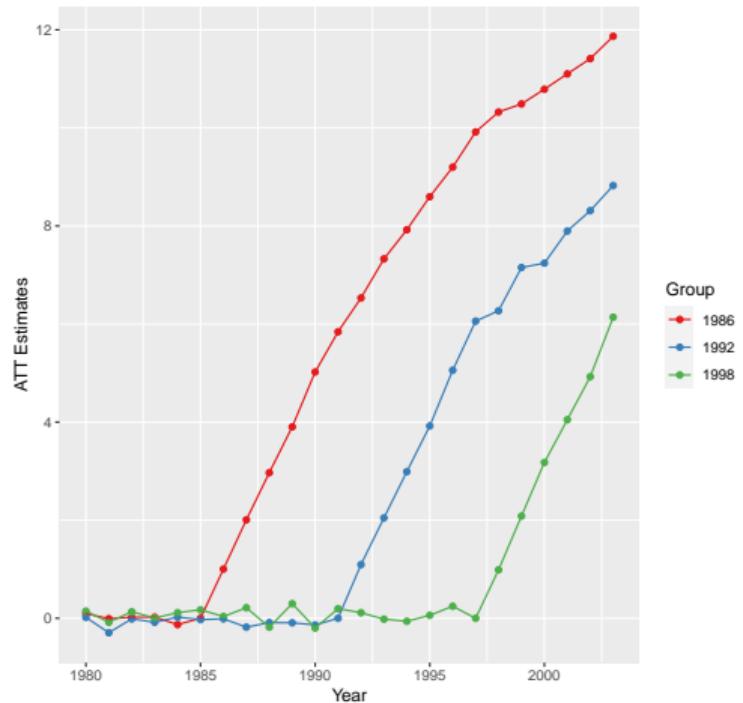
$$\text{ATT}^{\text{nev}}(g, t) = \mathbb{E}[Y_t - Y_{g-1} | G = g] - \mathbb{E}[Y_t - Y_{g-1} | C = 1].$$

- Use not-yet-treated (ny) groups:

$$\text{ATT}^{\text{ny}}(g, t) = \mathbb{E}[Y_t - Y_{g-1} | G = g] - \mathbb{E}[Y_t - Y_{g-1} | D_t = 0, G \neq g].$$

Callaway and Sant'Anna (2021)

Figure 4: Estimates of ATT



Any questions?

References 1

CALLAWAY, B. AND P. H. SANT'ANNA (2021): "Difference-in-Differences with multiple time periods," *Journal of Econometrics*, 225, 200–230, themed Issue: Treatment Effect 1.