Difference in Difference Models

Bill Evans

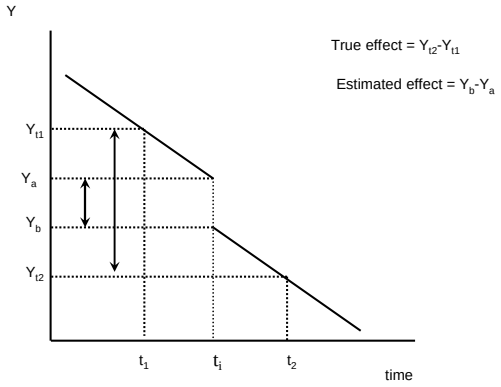
Spring 2008

Difference in difference models

- Maybe the most popular identification strategy in applied work today
- Attempts to mimic random assignment with treatment and "comparison" sample
- Application of two-way fixed effects model

Problem set up

- Cross-sectional and time series data
- One group is 'treated' with intervention
- Have pre-post data for group receiving intervention
- Can examine time-series changes but, unsure how much of the change is due to secular changes



- Intervention occurs at time period t_1
- True effect of law
  - $Y_a - Y_b$
- Only have data at t_1 and t_2
  - If using time series, estimate $Y_{t1} - Y_{t2}$
- Solution?

5

Difference in difference models

- Basic two-way fixed effects model
  - Cross section and time fixed effects
- Use time series of untreated group to establish what would have occurred in the absence of the intervention
- Key concept: can control for the fact that the intervention is more likely in some types of states

6

Three different presentations

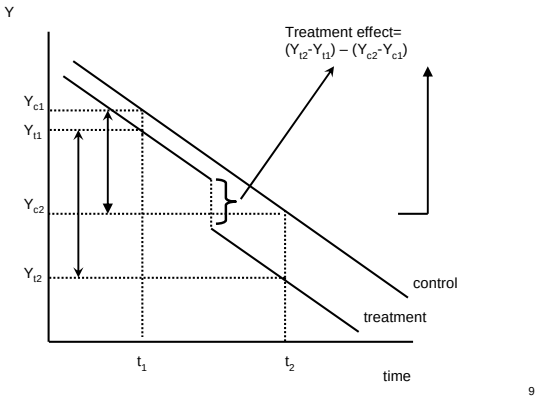
- Tabular
- Graphical
- Regression equation

7

Difference in Difference

	Before Change	After Change	Difference
Group 1 (Treat)	Y_{t1}	Y_{t2}	$\Delta Y_t = Y_{t2}-Y_{t1}$
Group 2 (Control)	Y_{c1}	Y_{c2}	$\Delta Y_c = Y_{c2}-Y_{c1}$
Difference			$\Delta\Delta Y$ $\Delta Y_t - \Delta Y_c$

8

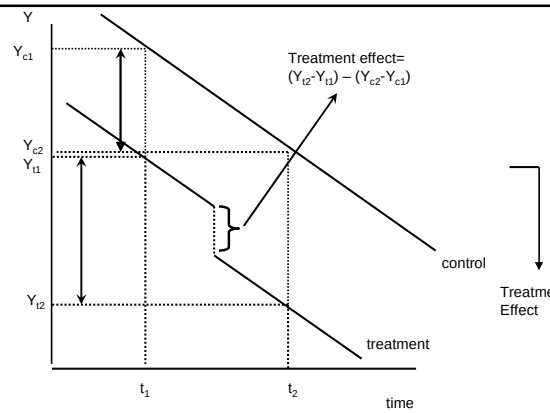


9

Key Assumption

- Control group identifies the time path of outcomes that would have happened in the absence of the treatment
- In this example, Y falls by Y_{c2}-Y_{c1} even without the intervention
- Note that underlying 'levels' of outcomes are not important (return to this in the regression equation)

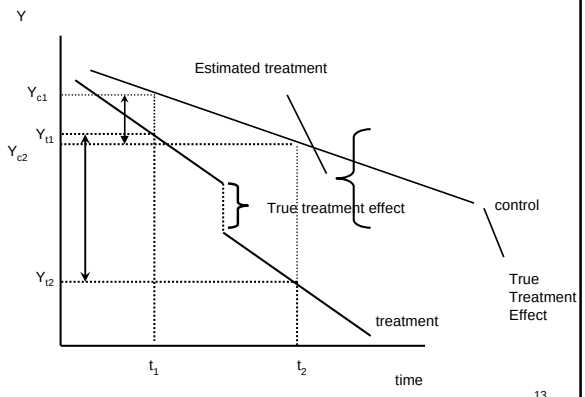
10



11

- In contrast, what is key is that the time trends in the absence of the intervention are the same in both groups
- If the intervention occurs in an area with a different trend, will under/over state the treatment effect
- In this example, suppose intervention occurs in area with faster falling Y

12



13

Basic Econometric Model

- Data varies by
  - state (i)
  - time (t)
  - Outcome is Y_{it}
- Only two periods
- Intervention will occur in a group of observations (e.g. states, firms, etc.)

14

- Three key variables
  - T_{it} =1 if obs i belongs in the state that will eventually be treated
  - A_{it} =1 in the periods when treatment occurs
  - $T_{it}A_{it}$ -- interaction term, treatment states after the intervention
- $Y_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 A_{it} + \beta_3 T_{it} A_{it} + \varepsilon_{it}$

15

$$Y_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 A_{it} + \beta_3 T_{it} A_{it} + \varepsilon_{it}$$

	Before Change	After Change	Difference
Group 1 (Treat)			
Group 2 (Control)			
Difference			

16

More general model

- Data varies by
  - state (i)
  - time (t)
  - Outcome is Y_{it}
- Many periods
- Intervention will occur in a group of states but at a variety of times

17

- u_i is a state effect
- v_t is a complete set of year (time) effects
- Analysis of covariance model

- $Y_{it} = \beta_0 + \beta_3 T_{it}A_{it} + u_i + \lambda_t + \varepsilon_{it}$

18

What is nice about the model

- Suppose interventions are not random but systematic
  - Occur in states with higher or lower average Y
  - Occur in time periods with different Y's
- This is captured by the inclusion of the state/time effects – allows covariance between
  - u_i and $T_{it}A_{it}$
  - λ_t and $T_{it}A_{it}$

19

- Group effects
  - Capture differences across groups that are constant over time
- Year effects
  - Capture differences over time that are common to all groups

20