Lecture 8 Differences-in-Differences

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Readings

- Angrist and Pischke chapter 5
- Carpenter and Dobkin (2011), "The Minimum Legal Drinking Age", *Journal of Economic Perspectives*, Vol. 25, No. 2, pp. 133-156

MLDA experiment

- The Minimum Legal Drinking Age (MLDA) varies across US states
- Alabama lowered its MLDA from 21 to 19 in 1975, but Arkansas kept the MLDA at 21
- We use a DD model to see what effect the reduction in the MLDA in Alabama had on the death rates of 18-20 year olds:

$$Y_{st} = \alpha + \beta TREAT_s + \gamma POST_t + \delta_{DD}(TREAT_s \times POST_t) + e_{st}$$

  - $TREAT_s$ is a dummy indicating Alabama
  - $POST_t$ is a dummy indicating years from 1975 onwards
  - $TREAT_s \times POST_t$ indicates observations for Alabama after the reduction in the MLDA
  - The DD coefficient δ_{DD} captures the effect of the reduction in the MLDA on youth death rates

MLDA experiment

- But DD does not need to be based on just two states and two time periods. Other states changed their MLDA at different times. For example, Tennessee lowered the MLDA from 21 to 18 in 1971 and increased it again to 19 in 1979.
- This complicates the analysis because there is no common post-treatment period.
- We address this issue by replacing the $POST_t$ dummy with a set of year dummies (with one omitted as a reference group, to avoid multicollinearity).
- The year dummies (*time fixed effects*) capture variation over time on youth death rates that are common to all states.
- To account for the fact that there are many states changing the MLDA, we replace the $TREAT_s$ dummy with a set of dummies for each state in the sample (with one omitted as a reference group) — *state fixed effects*

MLDA experiment

- Another complication of this multi-state multi-year scenario is the absence of a common treatment variable. The MLDA varies across states from age 18 to age 21.
- We account for this by replacing the interaction $TREAT_s \times POST_t$ with a variable capturing the *exposure* to the policy, $LEGAL_{st}$.
- This variable measures the proportion of 18-20 year olds allowed to drink in state s and year t. In same states, no one under 21 is allowed to drink. In states where the MLDA is 19, about two-thirds of 18-20 year olds can drink. In states where the MLDA is 18, all 18-20 year olds can drink.
- The definition of $LEGAL_{st}$ also captures the timing of the policy. For example, Alabama lowered the MLDA to 19 in July 1975, so $LEGAL_{AL,1975}$ is scaled to reflect the fact that two-thirds of 18-20 year olds were free to drink for only half of the year.

MLDA experiment

- Multi-state and multi-year DD model:

$$Y_{st} = \alpha + \delta_{DD} LEGAL_{st} + \sum_{k=Alaska}^{Wyo\,\min g} \beta_k STATE_{ks} + \sum_{j=1971}^{1983} \gamma_j YEAR_{jt} + e_{st}$$

- There is one dummy variable for each state except one (Alabama) and one dummy variable for each year except one (1970)
- The dataset has 14 years (1970 to 1983) and 51 states, so it has 714 observations. It is a panel dataset.

MLDA experiment

- The state fixed effects control for fixed differences between states (for example, fatal car accidents are more common in rural states with high average travel speeds).
- The year fixed effects control for trends in death rates that are common to all states (for example, because of national policies on vehicle safety).
- Changes in mortality rates within states are attributed to changes in the MLDA.

MLDA experiment

- Results:
  - Legal access to alcohol causes about 11 additional deaths per 100,000 18-20 year olds, of which 7 or 8 deaths are due to motor vehicle accidents.
  - There is no evidence of an effect of legal drinking on deaths from internal causes.

MLDA experiment

TABLE 5.2
Regression DD estimates of MLDA effects on death rates

Dependent variable	(1)	(2)	(3)	(4)
All deaths	10.80	8.47	12.41	9.65
	(4.59)	(5.10)	(4.60)	(4.64)
Motor vehicle accidents	7.59	6.64	7.50	6.46
	(2.50)	(2.66)	(2.27)	(2.24)
Suicide	.59	.47	1.49	1.26
	(.59)	(.79)	(.88)	(.89)
All internal causes	1.33	.08	1.89	1.28
	(1.59)	(1.93)	(1.78)	(1.45)
State trends	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Probing DD assumptions

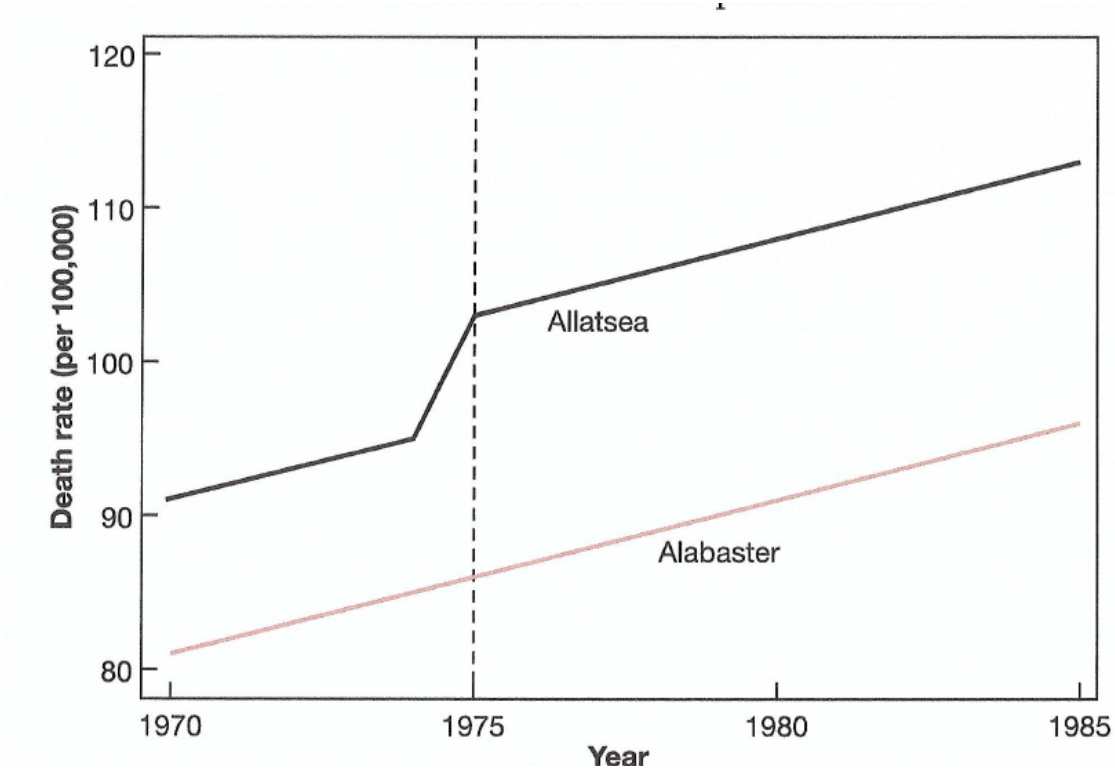
- The interpretation of changes in mortality rates within states as being caused by changes in the MLDA relies on the *common trends assumption* — in the absence of a change in the MLDA, death rates in states that lowered the MLDA (such as Allatsea) would have followed the same trend as death rates in states that did not change the MLDA (such as Alabaster).
- When we have many states and many years, we can allow for state-specific trends:

$$\begin{aligned} Y_{st} &= \alpha + \delta_{DD} LEGAL_{st} + \sum_{k=Alaska}^{Wyo\,\min g} \beta_k STATE_{ks} + \\ &\quad \sum_{j=1971}^{1983} \gamma_j YEAR_{jt} + \sum_{k=Alaska}^{Wyo\,\min g} \theta_k (STATE_{ks} \times t) + e_{st} \end{aligned}$$

  - where t is a linear trend

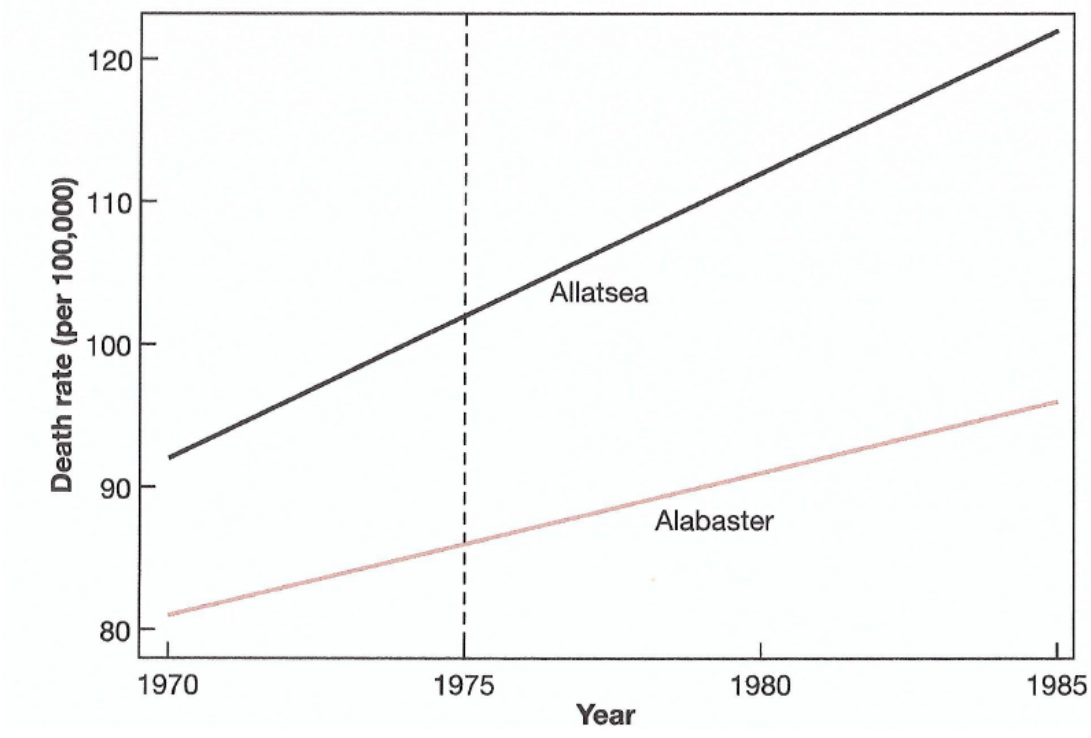
Probing DD assumptions

- Common trends



Probing DD assumptions

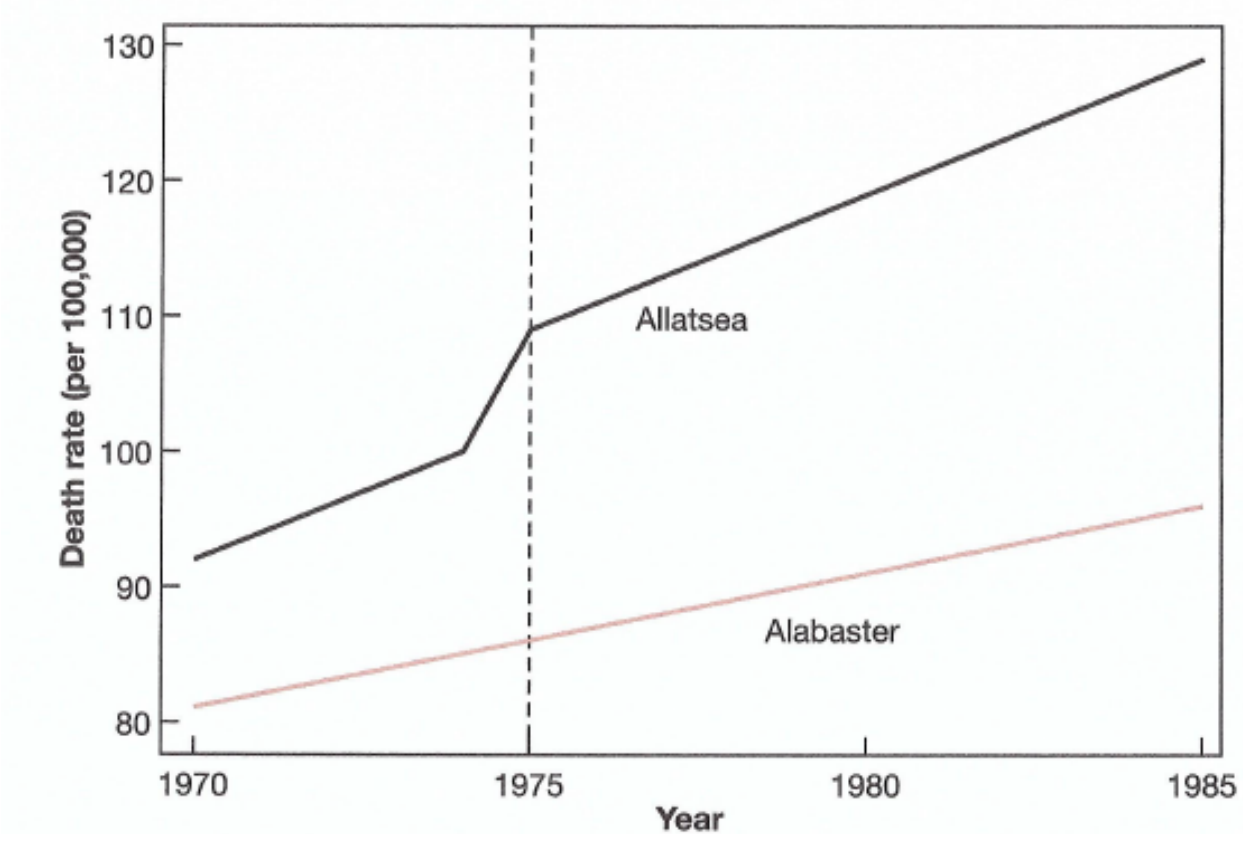
- Steeper trend in Allatsea than Alabaster



- DD estimation would say that the reduction in the MLDA increased deaths in Allatsea, but the difference in trends pre-dates the reduction in the MLDA in Allatsea, so there is no causal effect of the MLDA.

Probing DD assumptions

- If there is a causal effect of the MLDA even with different state trends, the model with state-specific trends will capture this effect.



Probing DD assumptions

- Comparing columns (1) and (2) in Table 5.2, we can see that the MLDA has an effect on youth deaths even when we include state-specific trends
- What other factors could be complicating the analysis?
  - There may be other variables that change in the state at the same time as the reduction in the MLDA. For example, states may raise tax rates on alcohol at the same time as they increase the MLDA, as part of a broader effort to reduce drinking.
  - We can take this into account by controlling for state beer taxes

Probing DD assumptions

- Results
  - Beer taxes do not have a significant effect on youth deaths
  - The effect of the MLDA is robust to the inclusion of the beer tax control

Probing DD assumptions

	Without trends		With trends	
Dependent variable	Fraction legal (1)	Beer tax (2)	Fraction legal (3)	Beer tax (4)
All deaths	10.98	1.51	10.03	−5.52
	(4.69)	(9.07)	(4.92)	(32.24)
Motor vehicle accidents	7.59	3.82	6.89	26.88
	(2.56)	(5.40)	(2.66)	(20.12)
Suicide	.45	−3.05	.38	−12.13
	(.60)	(1.63)	(.77)	(8.82)
Internal causes	1.46	−1.36	.88	−10.31
	(1.61)	(3.07)	(1.81)	(11.64)

Weighting in DD regressions

- In the regressions done so far, all observations are given equal weight. But some states (like Texas) are bigger than others (like Vermont). We can reflect this by giving more weight to states with a larger population,
- *Weighted Least Squares (WLS)* — minimises the sum of the squares of the residuals, weighting each term by population size (in this case).
- Using weights may increase the precision of the estimates, because larger states have more reliable data.
- But using weights is not necessarily a good idea. The typical citizen is more likely to live in Texas than Vermont, but changes in the MLDA in Vermont provide variation that may be just as useful as changes in Texas.

Weighting in DD regressions

- What we would like to see is that the regression estimates are not very different with and without weights.
- Columns (3) and (4) in Table 5.2 report the WLS results using population weights. The results are not very different to the ones without weights.