Difference-in-Difference:

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Methods Overviews

- Adding control variables

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    - Option B give the banks some cash so they don't collapse.

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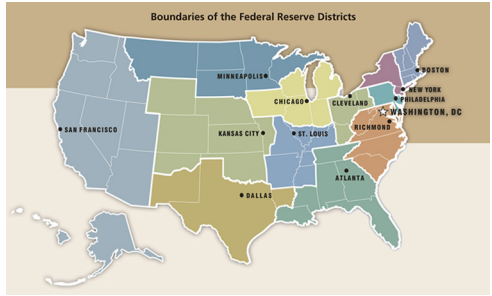
- Each of them manage banks from a particular geographical area (called districts).



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- During the 1930s, a bank-run started in Nashville, TN in the bank of Nashville and quickly spread out the neighboring areas.

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  - Different states, etc.

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  - It's hard to construct a story about a bank locating somewhere because they thought they would receive a treatment.
- However, we can come up with stories about banks locating in south/north region of the Mississippi, because of things like rent, projects, employment levels.

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- What happened to the banks on each district? Which district fare better? the ones from the ATL or STL?

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- "After the collapse, the 8th district that 11 more banks than the 6th district"
- "After the collapse, the 8th district had 9 percent more banks than the 6th district"
- What's another comparison we can do?

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- Can we do better?

Pre-Post Analysis

	1930 (Pre)	1931 (Post)	Diff
8th District STL	165	132	-33
6th District ATL	135	121	-14

- Specifically ATL appears to have saved 19 banks (more than 10% of those operating in Mississippi (19/135))

DD - Bank run

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- 19 is what we call the "Difference-in-Difference Estimate".

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  - We look for instances where we have a "treated" unit and a "control" unit.
  - Then we compare their outcomes before and after the intervention.
- This is a method to obtain causal inference in which we compare the treated units before and after the treatment to control units.

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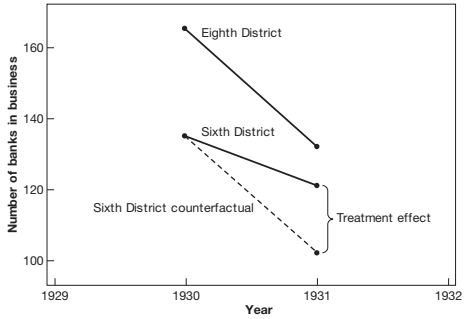
- Notice that this set-up requires to observe the treatment and the control group for more than 2 time period (i.e. panel data).
- What is then a key assumption that we are making in order for DD to recover the causal effect?
  - That in the absence of the reform/policy, the treatment group would have evolved in a similar way than the control group.

DD - Counterfactual

FIGURE 5.1
Bank failures in the Sixth and Eighth Federal Reserve Districts

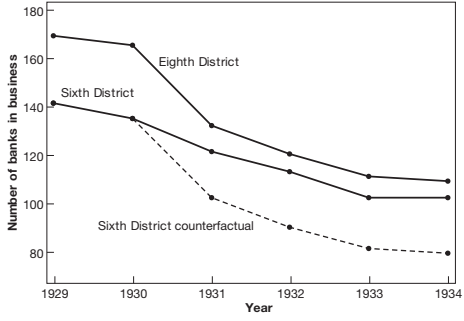


Notes: This figure shows the number of banks in operation in Mississippi in the Sixth and Eighth Federal Reserve Districts in 1930 and 1931. The dashed line depicts the counterfactual evolution of the number of banks in the Sixth District if the same number of banks had failed in that district in this period as did in the Eighth.

- We are using the 8th district (no treatment) as the counterfactual of what would have happened to the 6th district had they not implemented any policy

Difference-in-Difference: Assumption

FIGURE 5.3
Trends in bank failures in the Sixth and Eighth Federal Reserve Districts, and the Sixth District's DD counterfactual



Notes: This figure adds DD counterfactual outcomes to the banking data plotted in Figure 5.2. The dashed line depicts the counterfactual evolution of the number of banks in the Sixth District if the same number of banks had failed in that district after 1930 as did in the Eighth.

- We are assuming that the treatment and control group are good counterfactual of each other.

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    - Some of these can be relaxed

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  - It didn't matter the two districts have different starting points,
  - They could have different X's. Different levels of observable and unobservable characteristics.
  - The key is to understand if they are following similar patterns and trends.

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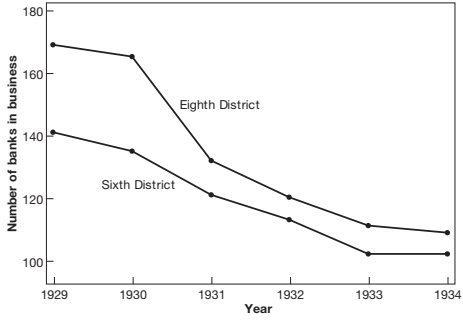
  - And that if the move in parallel, then they are being good counterfactual with each other.

DD- Parallel Trends

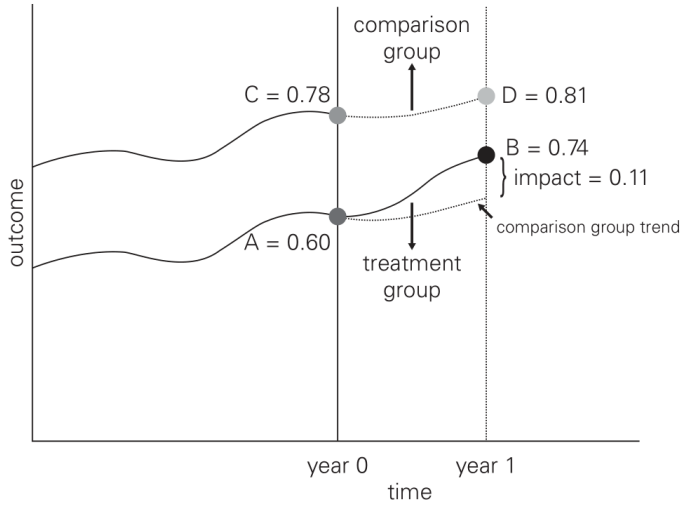
FIGURE 5.2
Trends in bank failures in the Sixth and Eighth Federal Reserve Districts



Note: This figure shows the number of banks in operation in Mississippi in the Sixth and Eighth Federal Reserve Districts between 1929 and 1934.

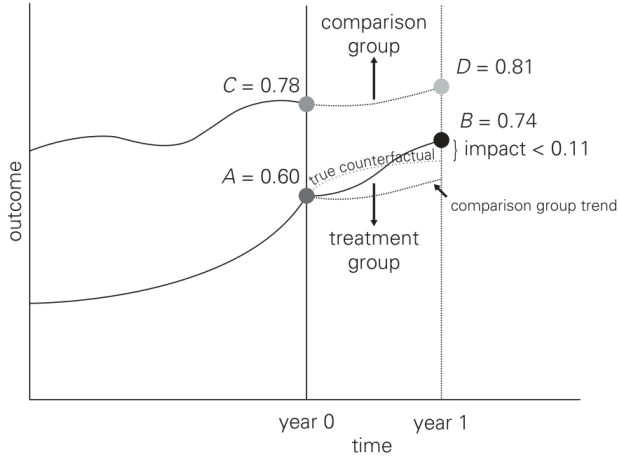
- An implication of the parallel trends is that, the more data we have pre-reform, the better because we can see how they evolve over long periods of time.

Parallel Trends assumptions



Source: Authors.

Parallel Trends assumption



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- Main Set up:

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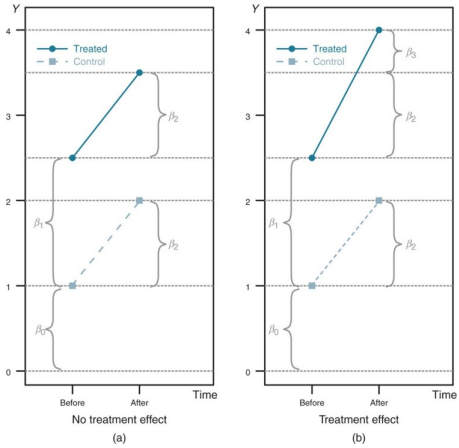
- How would we graph this?

Linear regressions and the graph



Practice Question

For each of the four panels below, indicate the values of β, γ, δ

$$Y_{dt} = \alpha + \beta\, Treat_d + \gamma Post_t + \delta_{DD}(Treat_d \times Post_t) + \varepsilon_{dt}$$

- Let's also do the reverse, let's pick numbers and then graph it

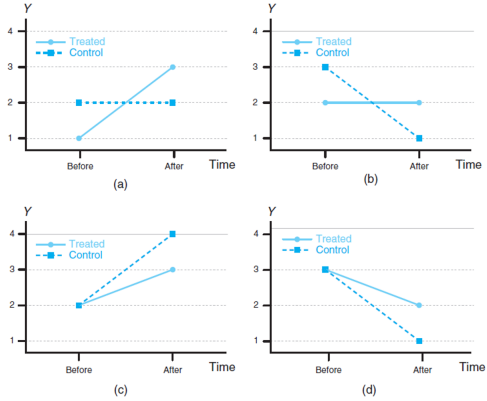


FIGURE 8.6: More Difference-in-Difference Examples (for Review Question)

STATA

- Say reform happeneed in year 2000, and treatment group is women with children

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- gen treat=0

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- replace post=1 if year>=2000

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- gen post=0
- replace post=1 if year>=2000
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STATA

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- `reg outcome i.treat##i.post`

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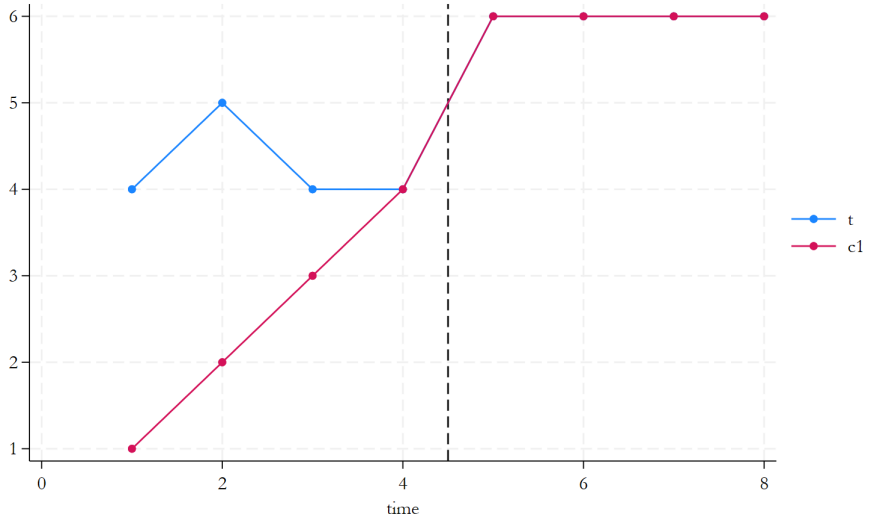
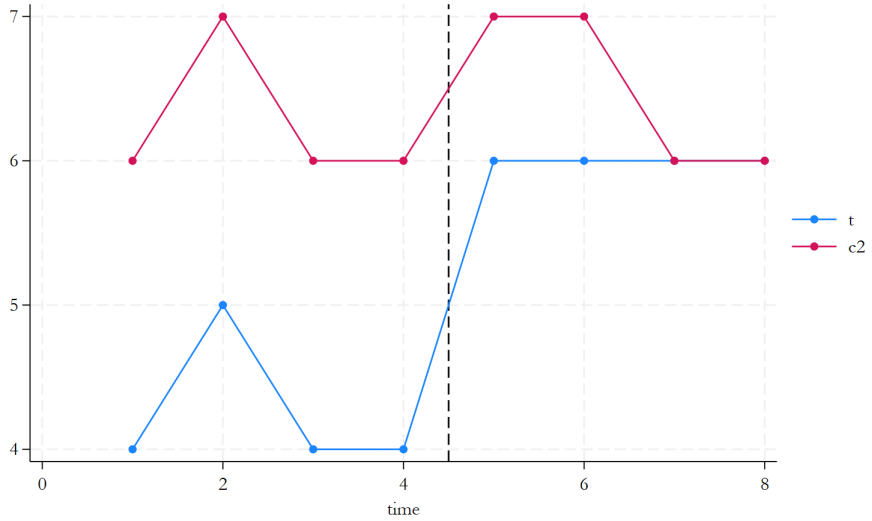
- Let's go over with some graphs to the intuition of what we want to test. **To the board & STATA**

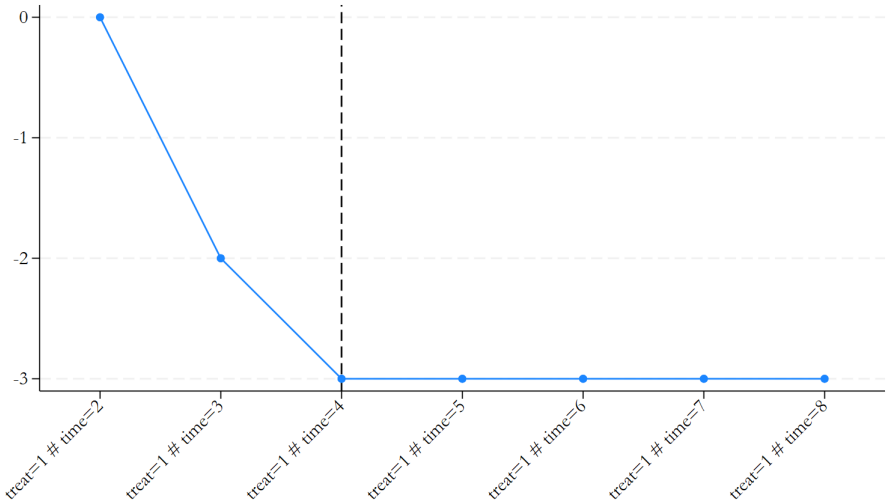
Event Study



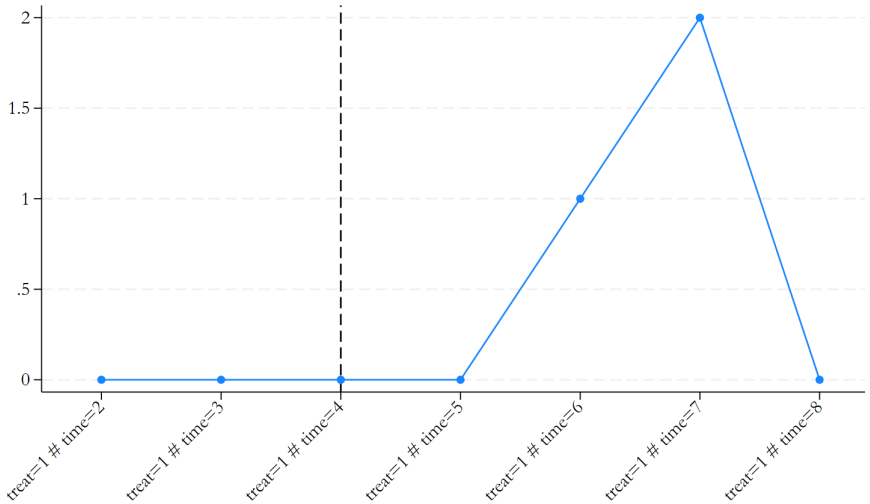
Event Study 2



Event Study


0
-1
-2
-3
treat=1 # time=2
treat=1 # time=3
treat=1 # time=4
treat=1 # time=5
treat=1 # time=6
treat=1 # time=7
treat=1 # time=8

Event Study 2



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- Event studies are a way to perform an empirical test of the parallel trends. Let's start with the main framework:

$$Y_{dt} = \alpha + \beta\, Treat_d + \gamma Post_t + \delta_{DD}(\boldsymbol{Treat_d} \times \boldsymbol{Post_t}) + X_{dt} + \varepsilon_{dt}$$

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- The main change is that we change the interaction, to be an interaction with every single time unit of the data. Let's say the time unit is years:

$$Y_{dt} = \alpha + \beta\, Treat_d + \gamma Post_t + X_{dt} + \delta_1\, Treat \times Year_1 + \delta_2\, Treat \times Year_2 \ldots + \delta_T\, Treat \times Year_T + \varepsilon_{dt}$$

$$Y_{dt} = \alpha_0 + \beta\, Treat_d + \gamma Post_t + X_{dt} + \sum_{i=1}^{t} \delta_i\, Treat \times Year_i + \varepsilon_{dt}$$

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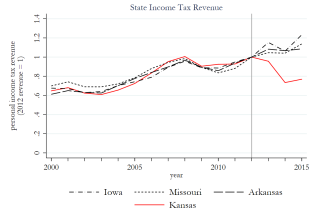
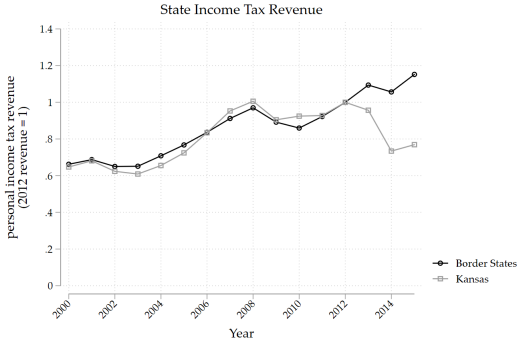
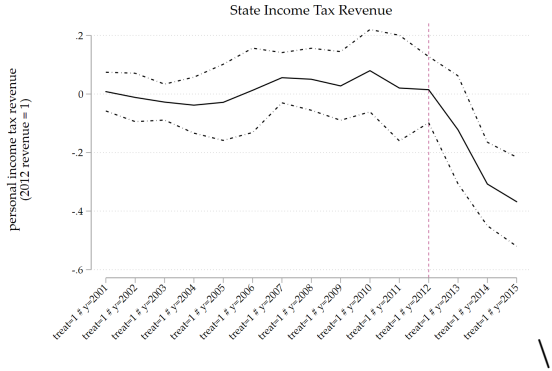


Event Study


State Income Tax Revenue
personal income tax revenue (2012 revenue = 1)
1.4
1.2
1
.8
.6
.4
.2
0
2000
2002
2004
2006
2008
2010
2012
2014
Year
Border States
Kansas

Event Study


State Income Tax Revenue
personal income tax revenue (2012 revenue = 1)
.2
0
-.2
-.4
-.6
treat=1 # y=2001
treat=1 # y=2002
treat=1 # y=2003
treat=1 # y=2004
treat=1 # y=2005
treat=1 # y=2006
treat=1 # y=2007
treat=1 # y=2008
treat=1 # y=2009
treat=1 # y=2010
treat=1 # y=2011
treat=1 # y=2012
treat=1 # y=2013
treat=1 # y=2014
treat=1 # y=2015

In Stata

- `fvset base 2011 year`

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- `reg outcome treat post i.treat#i.year, cl(fips)`

treat#year						
1 2000	-.0204675	.0548879	-0.37	0.734	-.1951453	.1542103
1 2001	-.0121733	.0629509	-0.19	0.859	-.2125113	.1881646
1 2002	-.0320695	.0534688	-0.60	0.591	-.2022312	.1380921
1 2003	-.0480236	.0519496	-0.92	0.423	-.2133503	.1173031
1 2004	-.0585066	.0352607	-1.66	0.196	-.170722	.0537087
1 2005	-.0488789	.0413734	-1.18	0.323	-.1805475	.0827897
1 2006	-.0077361	.06085	-0.13	0.907	-.2013878	.1859156
1 2007	.0353768	.0489586	0.72	0.522	-.1204315	.1911851
1 2008	.0300801	.03773	0.80	0.484	-.0899935	.1501537
1 2009	.007196	.0281234	0.26	0.815	-.0823052	.0966973
1 2010	.0593568	.0122813	4.83	0.017	.0202721	.0984414
1 2012	-.0056218	.0272642	-0.21	0.850	-.0923886	.0811449
1 2013	-.1427703	.0229417	-6.22	0.008	-.2157809	-.0697596
1 2014	-.3280348	.0176562	-18.58	0.000	-.3842248	-.2718448
1 2015	-.3885654	.054395	-7.14	0.006	-.5616746	-.2154561
_cons	.9223457	.0272642	33.83	0.000	.835579	1.009113

Generalizing DD

- One last point on the DD equation is that we can make the model "more flexible" by using more flexible fixed-effects

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- We will change Post and Treat variables for group fixed-effects (could be anything) and time-fixed effects

Changing *Post*

$$Y_{dt} = \alpha + \beta\, Treat_d + \gamma \boldsymbol{Post_t} + \delta_{DD}(Treat_d \times Post_t) + X_{dt} + \varepsilon_{dt}$$

- The "post" represented the change in the control group after the time period when the policy was implemented. The spirit of this was to control for other things that are going on in the post period that are affecting the treatment and control group.

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  - Notice that it doesn't just have to be state, it can be "units" FE, where "units" represents units getting the treatment.

Event study

- Our main regressions could look like

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- What would some economic models predict and why?
  - The increase in marginal costs associated with the gasoline self-service ban leads to a reduction in supply and a subsequent increase in gasoline prices.
  - If the marginal costs of gasoline stations are constant, there should be a near 100% pass-through of costs to prices and the effect of the self-service ban on gasoline prices could be entirely attributed to the change in supply

Set up

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- Though, we don't know the data structure, what could be some set-ups for DD?

Data

- The gasoline price data used to create the dependent variable in my analysis reflects the daily price, reported to the mobile application GasBuddy by gasoline consumers, for each station in the state of Oregon from January 1, 2016, to December 31, 2019.

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- Knowing the data structure, would would you recommend as the DD set-up?

Empirical Strategy

EMPIRICAL STRATEGY

I estimate the impact of self-service bans in the retail gasoline market on gasoline prices by using the 2018 repeal of this ban in counties with less than 40,000 citizens in Oregon as a natural experiment. That is, I compare changes in gasoline prices in treated counties (with population below 40,000) to those of control counties (with population above 40,000) in Oregon before and after the repeal.

My primary specification estimates a difference-in-differences model with county fixed effects and time (monthly) fixed effects given by:

$$GasolinePrice_{it} = \gamma_i + \sigma_t + \beta_1 * 1[After2018 * Treated]_{it} + X_{it}\lambda + e_{it}. \quad (1)$$

Here, i indexes county and t indexes the date. $1[After2018 * Treated]$ indicates if a county has repealed the self-service ban at a given time period. Thus, it equals 1 if a county is treated and the date is after January 1, 2018, and it equals 0 otherwise. $1[After2018 * Treated]$ is the variable of interest, and its coefficient is my estimate of the ATT. γ_i represents a vector of county level fixed effects and

σ_t represents a vector of monthly fixed effects. The dependent variable, *GasolinePrices*, represents the average daily price of retail gasoline in each county. I represent the matrix of unemployment, population, poverty rate, and median income measures by X_{it}. The error term is represented by e_{it}.

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- What role do fixed effects play in the regression? Why does the model include both county and time fixed effects?
- What is the key identifying assumption for difference-in-differences to yield causal estimates in this study? How does the author test it?

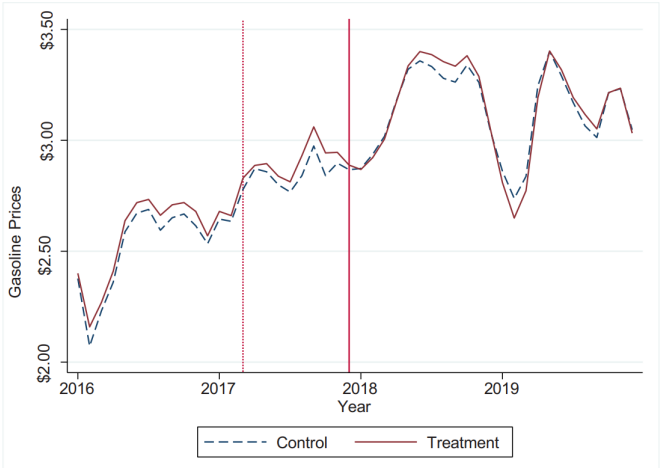
Assumption

RESULTS

Parallel trends assumption

The estimates of the ATT from the difference-in-differences model rely on the assumption of parallel trends. Thus, the validity of the effects found in this study requires substantial evidence to support this assumption. Figure 2 shows the average gasoline prices of the control counties (with population above 40,000 people) represented by the dashed line and the treated counties (with population below 40,000 people) represented by the solid line. The vertical solid line represents the last month of 2017, which is the month immediately prior to the policy change that repealed the self-service ban in some counties. The dashed vertical line shows the time when the repeal of the self-service ban was announced. Note that the repeal of the self-service ban applies primarily to the rural eastern part of Oregon, which is known to be very different from the coastal part of Oregon. However, these distinct characteristics in Oregon counties will not bias the results from the difference-in-differences model as long as the parallel trends assumption holds.

Figure


Gasoline Prices
$2.00
$2.50
$3.00
$3.50
2016
2017
2018
2019
Year
Control
Treatment

Results

TABLE 2 Simple differences in gasoline prices.

	Pre-treatment mean	Post-treatment mean	Differences	Difference-in differences
Treated group	270.23	313.62	43.38	−4.23
Control group	265.11	312.78	47.61	

Notes: This table shows a simple 2×2 comparison of the change in average prices from the pre-treatment period to the post-treatment period for treated and control counties. This difference in differences suggests that the self-service repeal reduced gasoline prices. A formal assessment of this effect is found in Tables 3 through 5.

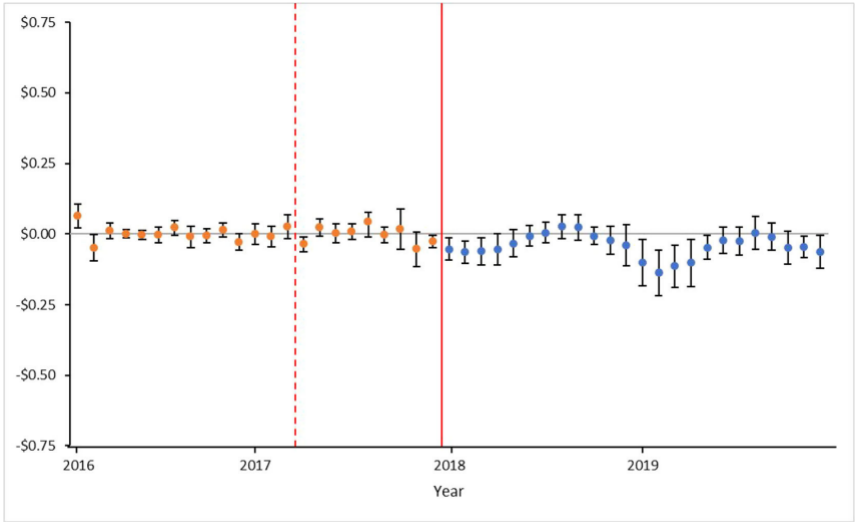
Results

TABLE 3 Effect of repealing self-service gasoline ban.

	(1)	(2)	(3)	(4)
Repeal (ATT)	−4.2***	−4.4***	−4.6***	−4.4***
	(1.65)	(1.69)	(1.74)	(1.7)
Unemployment rate		Yes	Yes	Yes
Poverty rate			Yes	Yes
Income				Yes
Time fixed effects	Yes	Yes	Yes	Yes
County fixed effects	Yes	Yes	Yes	Yes
Observations	42,961	42,961	42,961	42,961
Treated counties	13	13	13	13
Control counties	18	18	18	18

Notes: The coefficient on Repeal (ATT) represents the estimated average treatment effect on the treated associated with the repeal of the self-service ban. Standard errors clustered at the county level are shown in parentheses. ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

Results



is 4.4 cents a lot? or not?

Although public polling suggests that a strong majority (63%) of Oregonians support giving drivers the choice to pump their own gas, some consumers have resisted efforts to lift the ban on self-service pumps (Degenhardt, 2023). Reasons cited include skepticism over price reductions, concerns that people with disabilities won't be able to fuel their vehicle without assistance, drivers may lack the skills to safely operate a pump, and that in inclement weather drivers would rather avoid the need to exit their vehicle to refuel. This research shows that the self-service ban repeal decreased gasoline prices in rural counties. Given that much of the competition in gasoline markets is over only a couple cents, the effect I uncover represents a substantial change in gasoline prices. A comparable tax that leads gasoline prices to increase by 4.4 cents would likely face an enormous amount of criticism and debate, which speaks to the economic relevance of this regulation. The effect of repealing this ban in urban Oregon counties and New Jersey may be even larger since gasoline stations are likely to pay higher wages in urban areas than rural areas.

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    - changing around the time where the outcomes change (Jan 2018).

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  - State policy change that affected all counties in 2016.

Considerations

- Given the results from the paper, for the following concerns that people may have discuss with a partner: is this a concern? if yes why, if not, what else would we need to state for this to be a concern?
  - Spillover effects: If drivers in control counties traveled to treated counties to benefit from lower prices.
  - Price data comes from GasBuddy, crowd-sourced by consumers. While this data has been validated in prior research, it may be noisier in rural areas with fewer reporters.
  - State policy change that affected all counties in 2016.
  - State policy change that affected all counties in 2019.

Examples

- What happens to voter turnout when you move to another place with higher voter turnout?

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- What does subsidizing legal counsel in poor communities do?

Examples

- What happens to voter turnout when you move to another place with higher voter turnout?
- What does subsidizing legal counsel in poor communities do?
- Does reducing taxes on small business actually pay for itself?

Legal Counsel

CHANGES IN FAMILY STRUCTURE AND WELFARE PARTICIPATION SINCE THE 1960S: THE ROLE OF LEGAL SERVICES*

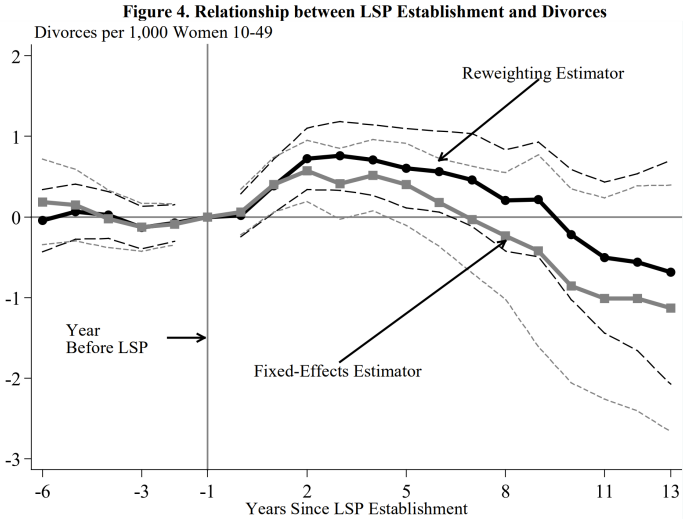
Jamein Cunningham
Andrew Goodman-Bacon

July 15, 2020

Abstract

This paper evaluates the effects of the War on Poverty's Legal Services Program (LSP) on family structure and welfare participation. LSPs provided subsidized legal assistance to poor communities, focusing on divorce and welfare access. We use a difference-in-differences research design based on the rollout of the program to 251 counties from 1965 to 1975. We find temporary increases in divorce and persistent increases in welfare participation and nonmarital birth rates. Nonmarital births rose because marriage rates fell, not because birth rates rose. Expanded access to legal institutions thus contributed, directly and indirectly, to changes in family structure in the 1960s.

Legal Counsel



Example: Voting

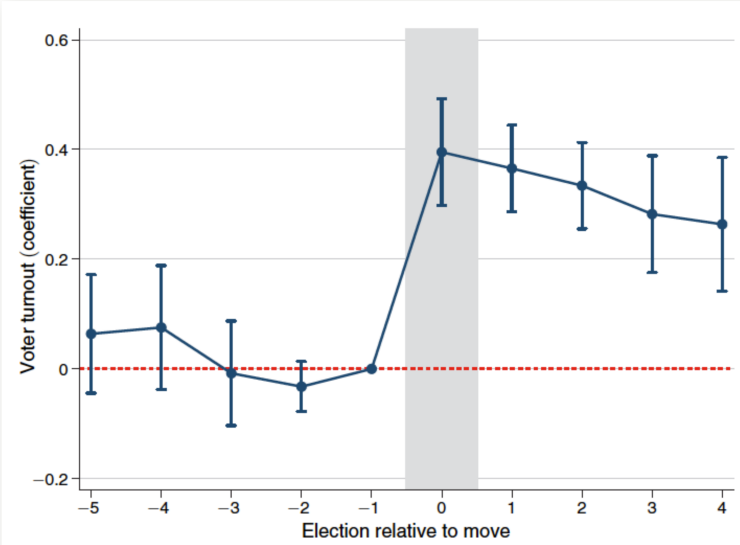


Figure 3 from Cantoni and Pons (2022)

Example

Effective Policy for Reducing Inequality? The Earned Income Tax Credit and the Distribution of Income
Hilary W. Hoynes and Ankur J. Patel
NBER Working Paper No. 21340
July 2015
JEL No. H2,I38,J2

ABSTRACT

In this paper, we examine the effect of the EITC on the employment and income of single mothers with children. We provide the first comprehensive estimates of this central safety net policy on the full distribution of after-tax and transfer income. We use a quasi-experiment approach, using variation in generosity due to policy expansions across tax years and family sizes. Our results show that a policy-induced $1000 increase in the EITC leads to a 7.3 percentage point increase in employment and a 9.4 percentage point reduction in the share of families with after-tax and transfer income below 100% poverty. Event study estimates show no evidence of differential pre-trends, providing strong evidence in support of our research design. We find that the income increasing effects of the EITC are concentrated between 75% and 150% of income-to-poverty with little effect at the lowest income levels (50% poverty and below) and at levels of 250% of poverty and higher. By capturing the indirect effects of the credit on earnings, our results show that static calculations of the anti-poverty effects of the EITC (such as those released based on the Supplemental Poverty Measure, Short 2014) may be underestimated by as much as 50 percent.

How to chose a control group?

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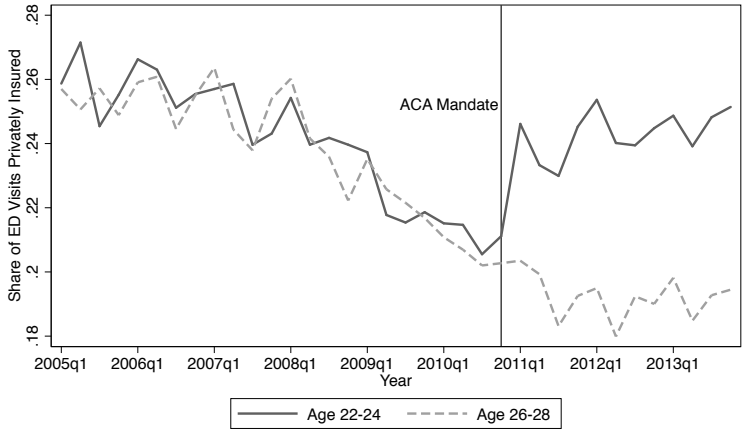
  - Age groups
- Usually want to rely on more than one control unit. We want to construct an average of other units.

Example: Age group



Other robustness checks

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- Get creative!

Extensions

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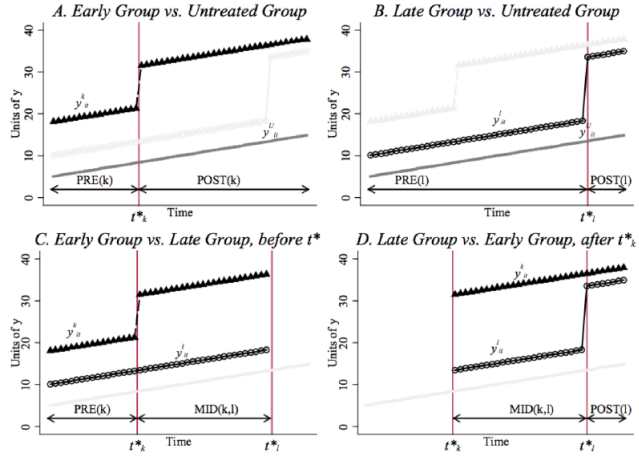
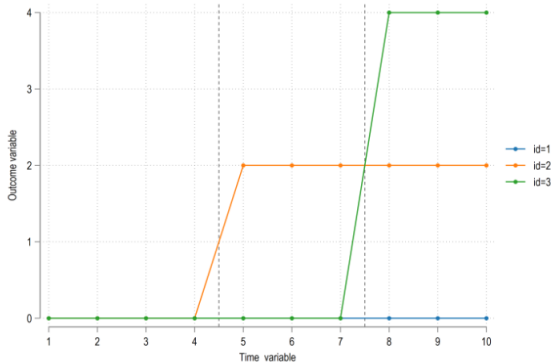
- What if treatment is similar but occurs in different places at different times?
  - Then we may have to be careful about comparisons in case there are heterogenous treatment effects

The problem of heterogenous time effects

Figure 2. The Four Simple (2x2) Difference-in-Differences Estimates from the Three Group Case

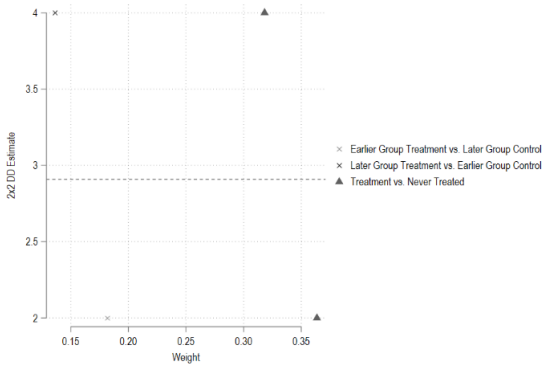


Bacon Decomposition in practice



- Make all possible comparison (DDs), and get the average of all of those comparisons

Bacon decomposition in practice



- Combine the numbers times the weights to get a weighted average, what do you get?

Bacon decomposition in practice

- When we run the regression, we get 2.9, why not 3?

Bacon decomposition in practice

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- Because OLS give the comparisons different weights:

```
Computing decomposition across 3 timing groups
including a never-treated group
------------------------------------------------------------------------------
           Y | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
           D |   2.909091   .3179908     9.15   0.000      2.28584    3.532341
------------------------------------------------------------------------------

Bacon Decomposition

+---------------------------------------------------+
|                     |         Beta   TotalWeight |
|---------------------+-----------------------------|
|        Early_v_Late |            2   .1818181841 |
|        Late_v_Early |            4   .1363636317 |
|      Never_v_timing |  2.933333323   .6818181841 |
+---------------------------------------------------+
```

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+---------------------------------------------------+
```

  - Where do the weights come from?

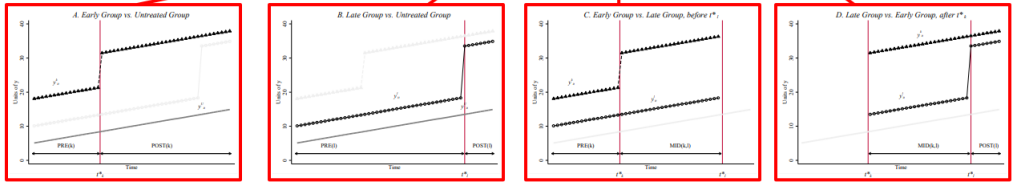
Bacon decomposition

Difference-in-Differences Decomposition Theorem (3 Group Case)

$$y_{it} = \alpha_i + \alpha_t + \hat{\beta}^{DD} D_{it} + u_{it}$$

For three groups:

$$\hat{\beta}^{DD} = s_{kU}\hat{\beta}^{2x2}_{kU} + s_{\ell U}\hat{\beta}^{2x2}_{\ell U} + s^{k}_{k\ell}\hat{\beta}^{2x2,k}_{k\ell} + s^{k}_{k\ell}\hat{\beta}^{2x2,\ell}_{k\ell}$$



Bacon decomposition: The weights

The weights are:

$$s_{kU} = \frac{(n_k + n_U)^2 \overbrace{n_{kU}(1 - n_{kU})\bar{D}_k(1 - \bar{D}_k)}^{\hat{V}^D_{kU}}}{\hat{V}^D}, \tag{10e}$$

$$s^k_{k\ell} = \frac{\left((n_k + n_\ell)(1 - \bar{D}_\ell)\right)^2 \overbrace{n_{k\ell}(1 - n_{k\ell})\frac{\bar{D}_k - \bar{D}_\ell}{1 - \bar{D}_\ell}\frac{1 - \bar{D}_k}{1 - \bar{D}_\ell}}^{\hat{V}^{D,k}_{k\ell}}}{\hat{V}^D}, \tag{10f}$$

$$s^\ell_{k\ell} = \frac{\left((n_k + n_\ell)\bar{D}_k\right)^2 \overbrace{n_{k\ell}(1 - n_{k\ell})\frac{\bar{D}_\ell}{\bar{D}_k}\frac{\bar{D}_k - \bar{D}_\ell}{\bar{D}_k}}^{\hat{V}^{D,\ell}_{k\ell}}}{\hat{V}^D}. \tag{10g}$$

and $\sum_{k \neq U} s_{kU} + \sum_{k \neq U} \sum_{\ell > k} \left[s^k_{k\ell} + s^\ell_{k\ell}\right] = 1.$

Bacon decomposition: Weights

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A. Early Group vs. Untreated Group

Size:
$$(n_k + n_U)^2$$
$$\times$$
Variance:
$$n_{kU}(1 - n_{kU})\bar{D}_k(1 - \bar{D}_k)$$

B. Late Group vs. Untreated Group

Size:
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*C. Early Group vs. Late Group, before t**

Size:
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*D. Late Group vs. Early Group, after t**

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Weights: $\frac{(subsample\ share)^2 (subsample\ variance\ of\ FE-adjusted\ D)}{total\ variance\ of\ FE-adjusted\ D}$

Bacon decomposition: What do the weights mean?

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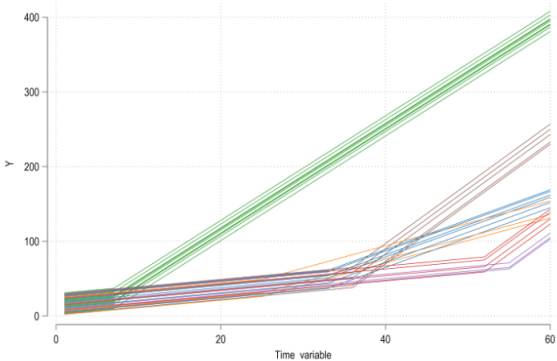
- This implies that: These weights end up giving a high degree of weight to the treated units in the middle of the sample (since they have the highest variance in the treatment indicator).

Bacon decomposition: Heterogenous Timing Effects

- These data was created with an effect for each unit that's between 2 and 10.



Bacon decomposition: Heterogenoud timing effects

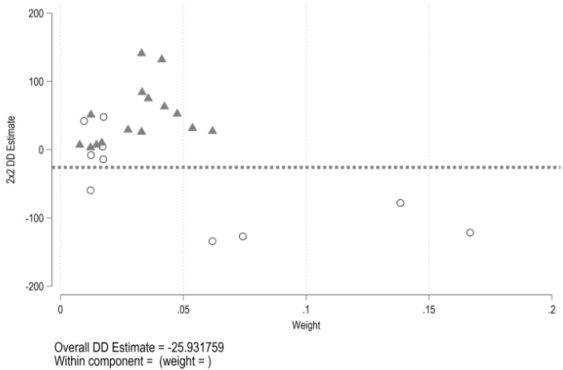
- But when we run the regression we get

```
HDFE Linear regression                            Number of obs   =      1,800
Absorbing 2 HDFE groups                           F(   1,   1710) =      59.04
                                                  Prob > F        =     0.0000
                                                  R-squared       =     0.8359
                                                  Adj R-squared   =     0.8273
                                                  Within R-sq.    =     0.0334
                                                  Root MSE        =    39.7334

------------------------------------------------------------------------------
           Y | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
           D |  -25.93176   3.374793    -7.68   0.000    -32.55092    -19.3126
       _cons |   114.9349   1.997427    57.54   0.000     111.0172    118.8525
------------------------------------------------------------------------------

Absorbed degrees of freedom:
-----------------------------------------------------+
 Absorbed FE | Categories  - Redundant  = Num. Coefs |
-------------+---------------------------------------|
          id |        30           0          30     |
           t |        60           1          59     |
-----------------------------------------------------+
```

Bacon decomposition: Heterogenous timing effects



Negative effects even when all the effects were positive!

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- https://asjadnaqvi.github.io/DiD/docs/01_stata/

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- https://asjadnaqvi.github.io/DiD/docs/01_stata/
- But think about other easy solutions!