Lecture 3:
Difference in Difference 1 of 2

September 20, 2023

Course Administration

1. Summaries are graded
2. One page proposals graded

Course Administration

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2. One page proposals graded
3. Problem set 2 posted
4. Will post answers to PS 1, including code
5. Any other issues?

Today

Diff-in-diff overview

1. When to use diff-in-diff
2. Simplest formulation: before and after only
3. With multiple obs before and after

Including a "trend" in a regression

Milligan and the Stork

1. Estimation problem
2. Data
3. Diff-in-diff in chart
4. Diff-in-diff in table
5. Diff-in-diff in regression

Motivating Diff-in-Diff

Motivating Diff-in-Diff

1. When should you use diff-in-diff?
2. Motivating example
3. Diff-in-diff v1
4. With potential outcomes notation
5. Writing and interpreting a diff-in-diff regression

Next time: validity tests and trends

0. Why Bother? Or, Why Not Regression with Covariates?

- OLS with covariates is unlikely to deliver a causal estimate of $\hat{\beta}$

0. Why Bother? Or, Why Not Regression with Covariates?

- OLS with covariates is unlikely to deliver a causal estimate of $\hat{\beta}$
- So we need a causal strategy
- Diff-in-diff is a causal strategy

1. When to use diff-in-diff?

When to Use a Difference in Difference Methodology?

- To evaluate the impact of a policy at an aggregate level
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- For example: national policy that affects some groups by not others
- Examples?

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- Where you have some potential control group
- Groups are frequently but not necessarily geographic
- For example: national policy that affects some groups by not others
- Examples? EITC evaluation that compares women with children versus those without

2. Motivating Example

Motivating Example: Card and Krueger, *AER*, 1991

Policy

- April 1992
  - NJ and PA have the same minimum wage of $4.25/hour
- April 1992 onward
  - NJ raises state minimum wage to $5.05/hour, no change in PA

Motivating Example: Card and Krueger, *AER*, 1991

Policy

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Data

- C&K collect data on employment and wages at fast food places in NJ and E PA
- observe data from February to November 1992

3. Diff-in-Diff Version 1

With This Setup, How Do We Estimate?

We observe

- Employment in NJ before and after
  - NJ_B and NJ_A
- Employment in PA before and after
  - PA_B and PA_A

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Why not $(NJ_A - NJ_B)$?

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$$(NJ_A - NJ_B) - (PA_A - PA_B)$$

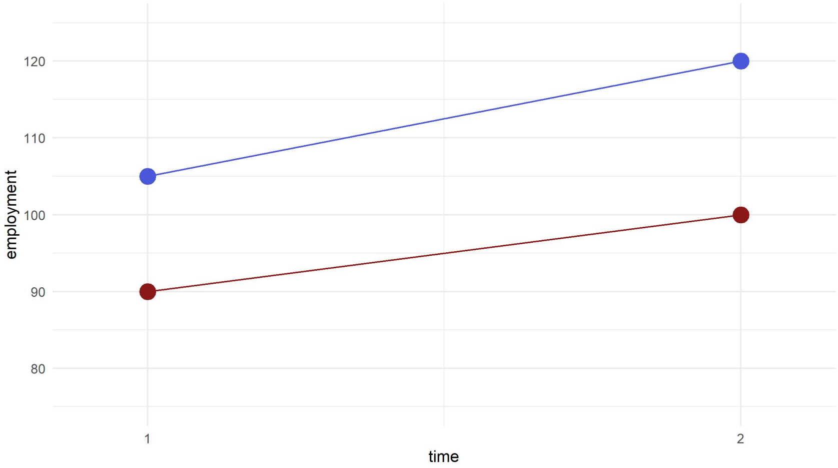
or

$$(NJ_A - PA_A) - (NJ_B - PA_B)$$

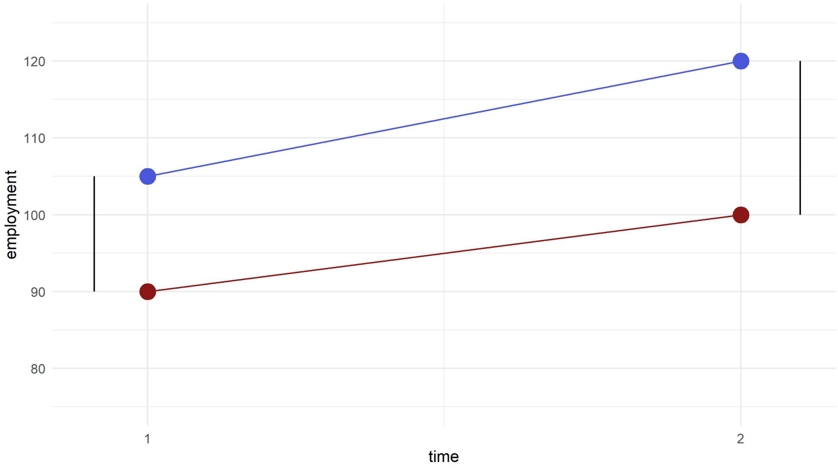
In Graph Form

This is NJ Only – Why Not This Comparison?

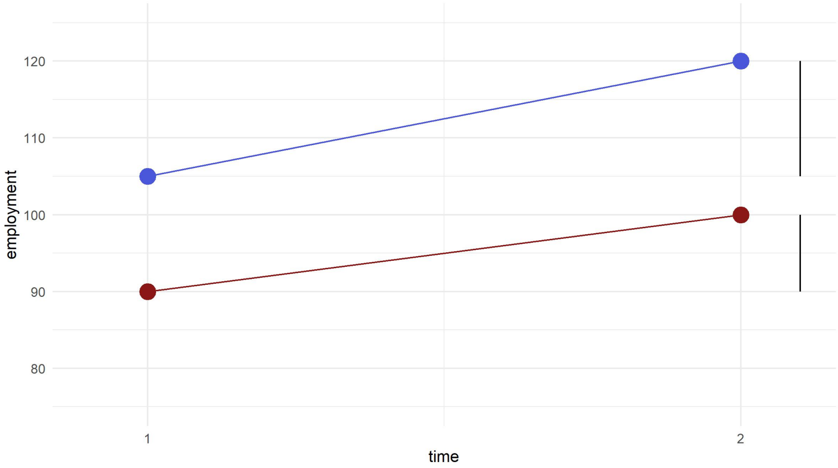
Here are Both: Where is Double Difference?



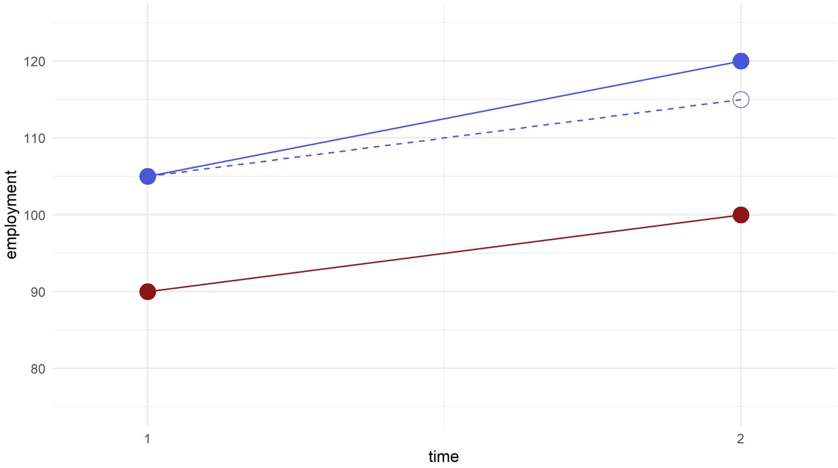
Double Difference v.1



Double Difference v.2



Or, the Implicit Comparison



4. Potential Outcomes Framework

Card and Krueger in a Potential Outcomes Framework

- $Y_{0ist} \equiv$ fast food employment at restaurant i, state s, period t with the low minimum wage
- $Y_{1ist} \equiv$ fast food employment at restaurant i, state s, period t with the high minimum wage
- Recall that we only observe one of these for any given t
- State $s \in \{\text{NJ}, \text{PA}\}$
- Time period $t \in \{\text{before}, \text{after}\}$

Key Assumptions

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   - This is the "common" or "parallel trends" assumption
2. $E[Y_{1ist} - Y_{0ist}|s,t] = \delta$
   - Change between treated and untreated states is a level difference – it's additive, not multiplicative, or some other function

5. Difference in difference estimation

Regression Specification and Interpretation

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- Note that you can estimate this with sample means! A very good place to start, for reasons we will talk about next week

Recap: Key Parts

Key Assumption

- In the absence of treatment, treatment and control observations would have evolved in parallel fashion
- AKA, "parallel trends"
- Fundamentally untestable
- Phrased differently: the only difference between treatment and control, apart from any level differences, is treatment

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Why a regression?

- a convenient way to get estimates and standard errors
- can do more policies (e.g. put in value of wage changes)
- can add controls, if parallel trend assumption is only valid conditionally, or if we want to reduce variance

Setting up the Milligan et al paper

Research Question and Estimation Problem

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  1. correlated with the treatment
  2. and with the outcome conditional on covariates (aka the error)
- Give an example of a potential omitted variable in this paper

Data and Units of Observation and Analysis

What are the two data sources?

Vital statistics data

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Canadian Census data

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  - $\rightarrow$ unit of observation is woman in a year
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Canadian Census data

- from 1991 and 1996
- covering five prior years
- unit of observation and analysis is family

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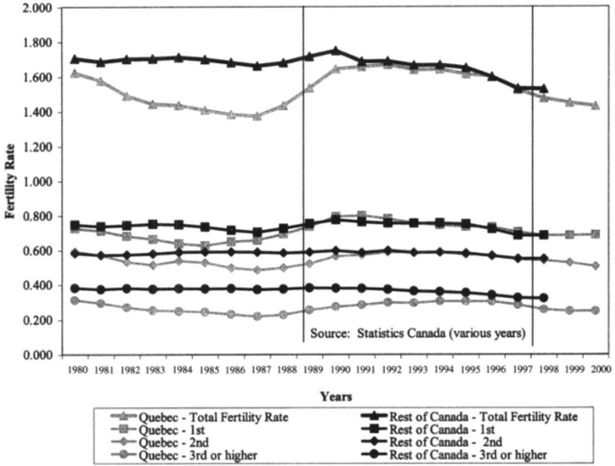
- We need
  - treated and untreated
  - before and after
- What are these here?
  - before and after: before ANC and during ANC
  - treated and untreated: Quebec and Rest of Canada

Estimation in Milligan

Basic Diff-in-diff in Figure 1

For the simplest diff-in-diff, what are the two comparisons?



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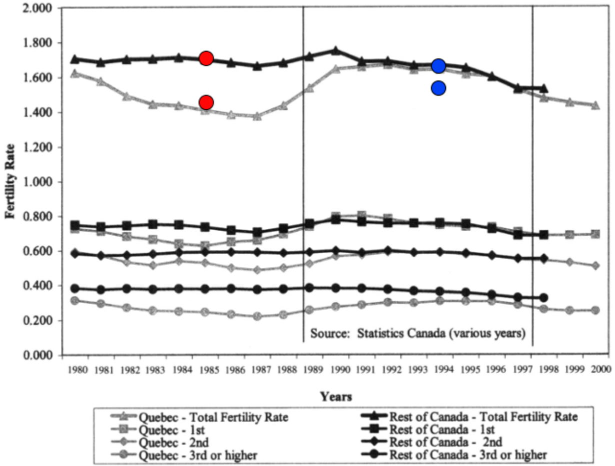

The Diff-in-diff in Table 5

Region	Mean 1991 (1)	Mean 1996 (2)	Trend Difference in Means, (2) − (1) = (3)	Difference in Differences (4)	Percentage Increase (5)
A. All Parities					
Quebec	0.418	0.451	0.033		
	(0.003)	(0.004)	(0.005)		
n	20,285	16,453			
Rest of Canada	0.432	0.441	0.009	0.024	5.5%
	(0.002)	(0.002)	(0.003)	(0.006)	
n	54,115	46,032			

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- And 0.441?

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- And 0.441?
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- How do we find 0.024?
- And 5.5%? (0.024)/(0.418+0.009)

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When estimated without covariates $X_{i,j,t}$, β_1 is **the same** as the estimate above.

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- Fertility in Quebec would have evolved like that in ROC absent the policy
- There are no pre-treatment trends in fertility in Quebec

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Can you test with Census data?

What is the Underlying Assumption Here?

Can state the assumption many different ways

- Only differences between Quebec and ROC are time-invariant
- Fertility in Quebec would have evolved like that in ROC absent the policy
- There are no pre-treatment trends in fertility in Quebec

Can you test with Census data? no – we only have one pre-treatment period

Table 6: Regression Version

Independent Variable	(a)	(b)
Pseudo R^2	0.0003	0.058
1996 dummy × Quebec	0.024* (0.005)	0.034* (0.006)
1996 dummy	0.009 (0.005)	0.013* (0.006)
Implied percentage increase in probability of having a child	5.6%	7.8%
Quebec	−0.014* (0.007)	−0.021* (0.007)
One older child	—	0.205* (0.016)
Two or more older children	—	−0.163* (0.011)
Female age 25–34	—	0.187* (0.009)
Female immigrant	—	0.032* (0.007)
Female Francophone	—	−0.047* (0.010)
Female Anglophone	—	−0.049* (0.012)
Female high school	—	−0.015* (0.006)
Female post–high school	—	−0.086* (0.004)
Female university degree	—	−0.192* (0.005)
Male age 25–34	—	—
Male age 35–44	—	—
Male age 45+	—	—
Male immigrant	—	—
Male Francophone	—	—
Male Anglophone	—	—
Male high school	—	—
Male post–high school	—	—
Male university degree	—	—
Married	—	—
Lives in urban area	—	—
Family income (C$10,000)	—	—
Provincial GDP growth	—	—
Provincial migration rate	—	—
Provincial education spending	—	—

- interpret coefficient for 1996 dummy
- interpret coefficient for 1996 dummy X Quebec

And a Triple Difference!

Region	Mean 1991 (1)	Mean 1996 (2)	Trend Difference in Means, (2) − (1) = (3)	Difference in Differences (4)	Percentage Increase (5)	Triple Difference (6)
A. All Parities						
Quebec	0.418	0.451	0.033			
	(0.003)	(0.004)	(0.005)			
n	20,285	16,453				
Rest of Canada	0.432	0.441	0.009	0.024	5.5%	
	(0.002)	(0.002)	(0.003)	(0.006)		
n	54,115	46,032				
B. *Zero older children*						
Quebec	0.393	0.418	0.025			
	(0.004)	(0.004)	(0.006)			
n	15,017	12,399				
Rest of Canada	0.398	0.407	0.009	0.016	4.0%	
	(0.002)	(0.003)	(0.003)	(0.007)		
n	38,754	33,338				
C. *One older child*						
Quebec	0.627	0.677	0.050			
	(0.009)	(0.009)	(0.013)			
n	3,207	2,475				
Rest of Canada	0.691	0.681	−0.010	0.060	9.7%	
	(0.005)	(0.006)	(0.008)	(0.015)		
n	8,262	7,088				
D. *Two or more older children*						
Quebec	0.278	0.353	0.075			
	(0.010)	(0.012)	(0.015)			
n	2,061	1,579				
Rest of Canada	0.321	0.344	0.023	0.052	17.2%	0.036
	(0.006)	(0.006)	(0.008)	(0.018)		(0.020)
n	7,099	5,606				

Next Lecture

- Read
  - Janssen and Zhang, selected pages
  - just through Section 4
- Summary due next week if you're on the list