# Lecture 3:
# Difference in Difference 1 of 2

January 29, 2023

# Course Administration

1. Summaries are graded
2. Thanks for proposals – will grade by next week
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

Next time: 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
- Where you have some potential control group

# When to Use a Difference in Difference Methodology?

- To evaluate the impact of a policy at an aggregate level
- 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?

# When to Use a Difference in Difference Methodology?

- To evaluate the impact of a policy at an aggregate level
- 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

- 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

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 $PA_A$

# With This Setup, How Do We Estimate?

Why not $(NJ_A - NJ_B)$?

We observe

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

# With This Setup, How Do We Estimate?

Why not $(NJ_A - NJ_B)$?

Estimating

We observe

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

# 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 $PA_A$

Why not $(NJ_A - NJ_B)$?
Estimating

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

# 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 $PA_A$

Why not $(NJ_A - NJ_B)$?
Estimating

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

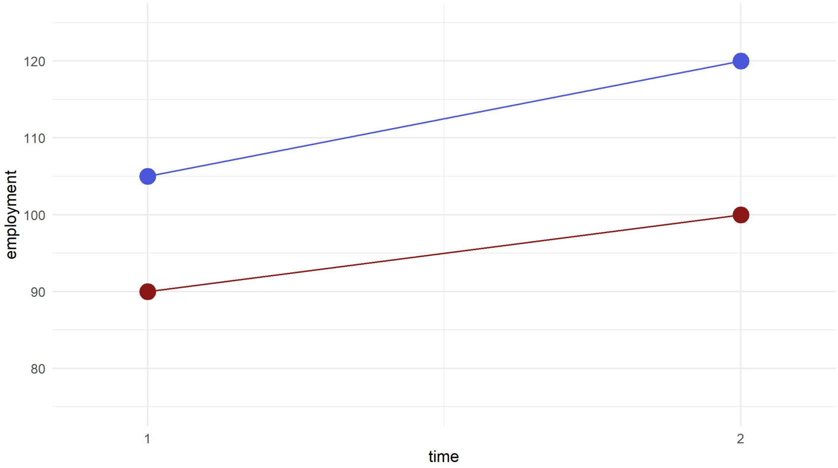
or

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

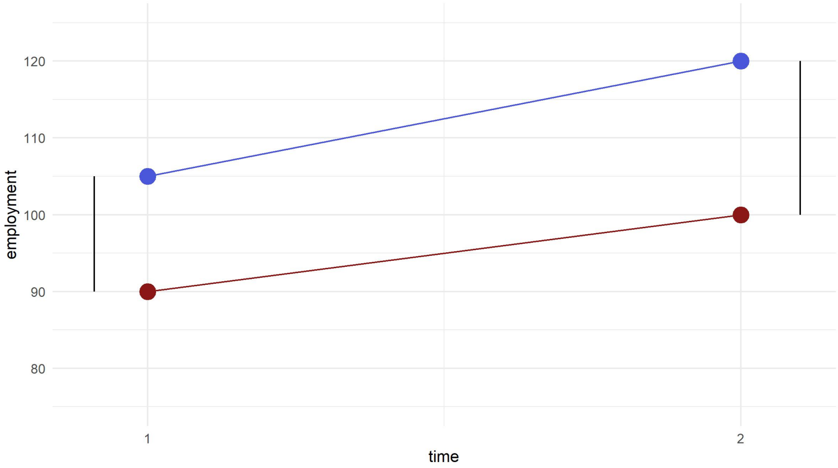
# In Graph Form

# This is NJ Only – Why Not This Comparison?

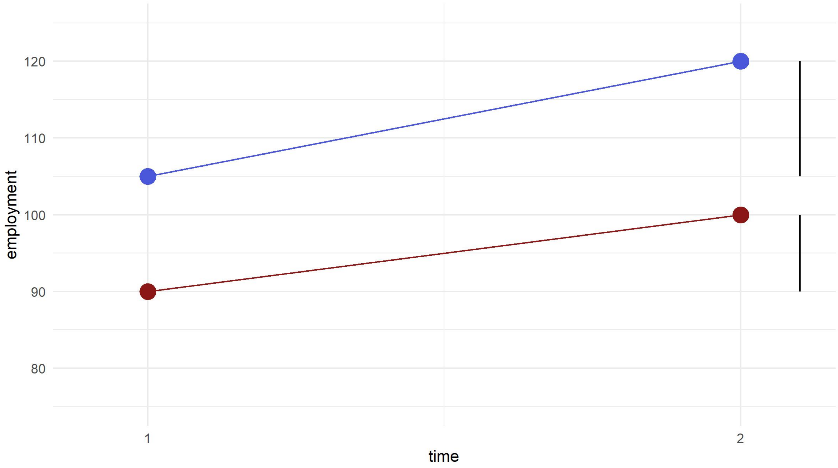
# Here are Both: Where is Double Difference?



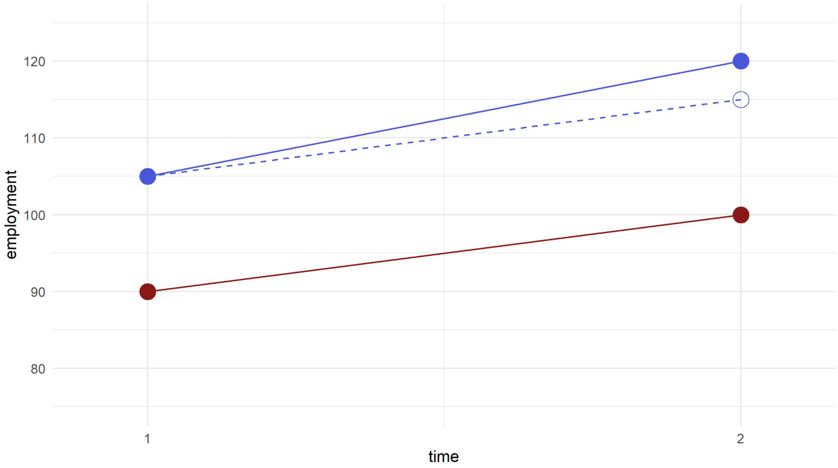
# Double Difference v.1



# 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

1. $E[Y_{0ist}|s, t] = \gamma_s + \lambda_t$

# Key Assumptions

1. $E[Y_{0ist}|s,t] = \gamma_s + \lambda_t$
   - $\gamma_s \equiv$ state fixed effects
   - $\lambda_t \equiv$ time fixed effects

# Key Assumptions

1. $E[Y_{0ist}|s, t] = \gamma_s + \lambda_t$
   - $\gamma_s \equiv$ state fixed effects
   - $\lambda_t \equiv$ time fixed effects
   - In words: the outcome, conditional on state and time, can be explained by something fixed about the state, and something fixed in a given time period for all states
   - Note that $\gamma_s$ does not have to be the same for all states
   - Give an example where you think this isn't true

# Key Assumptions

1. $E[Y_{0ist}|s,t] = \gamma_s + \lambda_t$
   - $\gamma_s \equiv$ state fixed effects
   - $\lambda_t \equiv$ time fixed effects
   - In words: the outcome, conditional on state and time, can be explained by something fixed about the state, and something fixed in a given time period for all states
   - Note that $\gamma_s$ does not have to be the same for all states
   - Give an example where you think this isn't true
   - This is the "common" or "parallel trends" assumption

# Key Assumptions

1. $E[Y_{0ist}|s,t] = \gamma_s + \lambda_t$
   - $\gamma_s \equiv$ state fixed effects
   - $\lambda_t \equiv$ time fixed effects
   - In words: the outcome, conditional on state and time, can be explained by something fixed about the state, and something fixed in a given time period for all states
   - Note that $\gamma_s$ does not have to be the same for all states
   - Give an example where you think this isn't true
   - 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

- In the regression world, we write the regression equation as

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

and note that $NJ_s * d_t$ is the treatment

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before?

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after?

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment

- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$
  - NJ before?

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$
  - NJ before? $\alpha + \gamma$

## Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$
  - NJ before? $\alpha + \gamma$
  - NJ after?

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$
  - NJ before? $\alpha + \gamma$
  - NJ after? $\alpha + \gamma + \lambda + \delta$

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$
  - NJ before? $\alpha + \gamma$
  - NJ after? $\alpha + \gamma + \lambda + \delta$
  - Can you see diff-in-diff?

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$
  - NJ before? $\alpha + \gamma$
  - NJ after? $\alpha + \gamma + \lambda + \delta$
  - Can you see diff-in-diff?

$$\text{(NJ after} - \text{NJ before)} - \text{(PA after} - \text{PA before)} \quad =$$

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$
  - NJ before? $\alpha + \gamma$
  - NJ after? $\alpha + \gamma + \lambda + \delta$
  - Can you see diff-in-diff?

$$\begin{aligned}(\text{NJ after} - \text{NJ before}) - (\text{PA after} - \text{PA before}) &= \\ ((\alpha + \gamma + \lambda + \delta) - (\alpha + \gamma)) - ((\alpha + \lambda) - (\alpha))\end{aligned}$$

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$
  - NJ before? $\alpha + \gamma$
  - NJ after? $\alpha + \gamma + \lambda + \delta$
  - Can you see diff-in-diff?

$$\begin{aligned} (\text{NJ after} - \text{NJ before}) - (\text{PA after} - \text{PA before}) &= \\ ((\alpha + \gamma + \lambda + \delta) - (\alpha + \gamma)) - ((\alpha + \lambda) - (\alpha)) &= \delta \end{aligned}$$

# Regression Specification and Interpretation

- In the regression world, we write the regression equation as

$$Y_{ist} = \alpha + \gamma NJ_s + \lambda d_t + \delta NJ_s * d_t + \epsilon_{ist}$$

  and note that $NJ_s * d_t$ is the treatment
- Break down this equation
  - PA before? $\alpha$
  - PA after? $\alpha + \lambda$
  - NJ before? $\alpha + \gamma$
  - NJ after? $\alpha + \gamma + \lambda + \delta$
  - Can you see diff-in-diff?

$$\begin{aligned}(\text{NJ after} - \text{NJ before}) - (\text{PA after} - \text{PA before}) &= \\ ((\alpha + \gamma + \lambda + \delta) - (\alpha + \gamma)) - ((\alpha + \lambda) - (\alpha)) &= \delta\end{aligned}$$

- 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

# 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

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

1. What is the research question?

# Research Question and Estimation Problem

1. What is the research question?
2. What does this mean? "... empirical researchers have shown great interest in trying to uncover evidence of a relationship between prices and fertility. The endogeneity of key variables has frustrated this effort.

# Research Question and Estimation Problem

1. What is the research question?
2. What does this mean? "... empirical researchers have shown great interest in trying to uncover evidence of a relationship between prices and fertility. The endogeneity of key variables has frustrated this effort. Women may have unobserved proclivities for different family sizes.

# Research Question and Estimation Problem

1. What is the research question?
2. What does this mean? "... empirical researchers have shown great interest in trying to uncover evidence of a relationship between prices and fertility. The endogeneity of key variables has frustrated this effort. Women may have unobserved proclivities for different family sizes. If differences in these proclivities lead to different human capital accumulation and marital decisions, then the opportunity cost of time out of the labor market will be jointly determined with fertility."

# Omitted Variable Bias

- What are the two components of an omitted variable problem/story? An omitted variable is

# Omitted Variable Bias

- What are the two components of an omitted variable problem/story? An omitted variable is
  1. correlated with the treatment
  2. and with the outcome conditional on covariates (aka the error)

# Omitted Variable Bias

- What are the two components of an omitted variable problem/story? An omitted variable is
  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

# What's the Argument for How the ANC Solves This Problem?

# What's the Argument for How the ANC Solves This Problem?

- **Large** subsidy – at peak $>$ \$15k today
- Plausibly not related to fertility
- Everyone in Quebec treated similarly
- $\rightarrow$ compare Quebec and Rest of Canada
- Can also use a triple difference

# Data and Units of Observation and Analysis

What are the two data sources?

Vital statistics data

# Data and Units of Observation and Analysis

What are the two data sources?

Vital statistics data

- from birth records

# Data and Units of Observation and Analysis

What are the two data sources?

Vital statistics data

- from birth records
  - $\rightarrow$ unit of observation is woman in a year

# Data and Units of Observation and Analysis

What are the two data sources?

Vital statistics data

- from birth records
  - $\rightarrow$ unit of observation is woman in a year
- aggregates to fertility rates by cohort/province/parity

# Data and Units of Observation and Analysis

What are the two data sources?

Vital statistics data

- from birth records
  - $\rightarrow$ unit of observation is woman in a year
- aggregates to fertility rates by cohort/province/parity
  - $\rightarrow$ unit of analysis is province/year

# Data and Units of Observation and Analysis

What are the two data sources?

Vital statistics data

- from birth records
  - → unit of observation is woman in a year
- aggregates to fertility rates by cohort/province/parity
  - → unit of analysis is province/year

Canadian Census data

# Data and Units of Observation and Analysis

What are the two data sources?

Vital statistics data

- from birth records
  - $\rightarrow$ unit of observation is woman in a year
- aggregates to fertility rates by cohort/province/parity
  - $\rightarrow$ unit of analysis is province/year

Canadian Census data

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

# Basic Diff-in-diff

- We need
  - treated and untreated
  - before and after

# Basic Diff-in-diff

- We need
  - treated and untreated
  - before and after
- What are these here?

# Basic Diff-in-diff

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

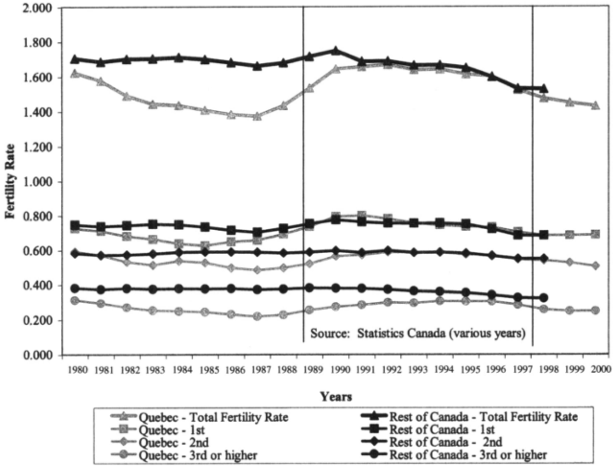
# Basic Diff-in-diff

- 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

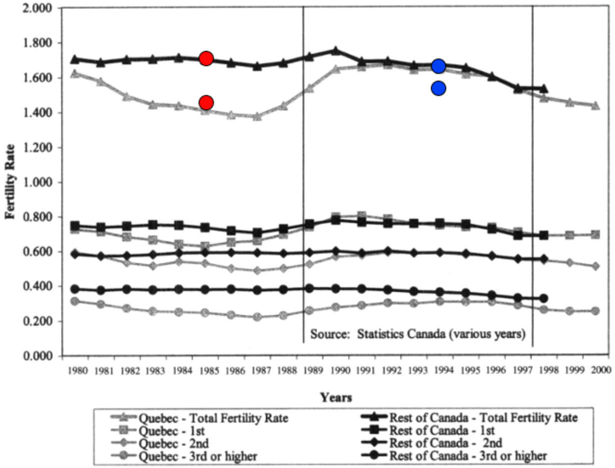
# Basic Diff-in-diff in Figure 1

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



# Basic Diff-in-diff in Figure 1

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



# 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 | | | |

- How do you calculate 0.418?

# 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 | | | |

- How do you calculate 0.418?
- And 0.441?

# 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 | | | |

- How do you calculate 0.418?
- And 0.441?
- And Col. 3, 0.033?

# 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 | | | |

- How do you calculate 0.418?
- And 0.441?
- And Col. 3, 0.033?

- How do we find 0.024?

# 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 | | | |

- How do you calculate 0.418?
- And 0.441?
- And Col. 3, 0.033?

- How do we find 0.024?
- And 5.5%?

# 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 | | | |

- How do you calculate 0.418?
- And 0.441?
- And Col. 3, 0.033?

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

# What Regression Equation Parallels the Diff-in-diff?

| 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 | | | |

# What Regression Equation Parallels the Diff-in-diff?

| 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 | | | |

$$\text{fertility}_{i,j,t} = \beta_0 + \beta_1 \text{Quebec}_i * 1\{t = 1996\}_t + \beta_2 \text{Quebec}_i + \beta_3 1\{t = 1996\}_t + \beta_4 X_{i,j,t} + \epsilon_{i,j,t}$$

# What Regression Equation Parallels the Diff-in-diff?

| 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 | | | |

$$\text{fertility}_{i,j,t} = \beta_0 + \beta_1 \text{Quebec}_i * 1\{t = 1996\}_t + \beta_2 \text{Quebec}_i + \beta_3 1\{t = 1996\}_t + \beta_4 X_{i,j,t} + \epsilon_{i,j,t}$$

When estimated without covariates $X_{i,j,t}$, $\beta_1$ is **the same** as the estimate above.

# What is the Underlying Assumption Here?

Can state the assumption many different ways

# 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

# 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?

# 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