Lecture 2:
Fixed Effects

September 6, 2023 – now September 13, 2023

Course Administration

1. Any problems with summary assignments?
   - I aspire to grade these weekly
2. Any problems accessing recorded lecture?
3. Proposal should be in – feedback by next week

Course Administration

1. Any problems with summary assignments?
   - I aspire to grade these weekly
2. Any problems accessing recorded lecture?
3. Proposal should be in – feedback by next week
4. ~~Lab session at 8:10 tonight~~
5. Lab session at 9 pm on zoom – see email

Course Administration

1. Any problems with summary assignments?
   - I aspire to grade these weekly
2. Any problems accessing recorded lecture?
3. Proposal should be in – feedback by next week
4. ~~Lab session at 8:10 tonight~~
5. Lab session at 9 pm on zoom – see email
6. Problem set 1 due next week
   - create your Box folder
   - invite me and Genevieve
7. Fixed date error with class Thanksgiving week

Course Administration

1. Any problems with summary assignments?
   - I aspire to grade these weekly
2. Any problems accessing recorded lecture?
3. Proposal should be in – feedback by next week
4. ~~Lab session at 8:10 tonight~~
5. Lab session at 9 pm on zoom – see email
6. Problem set 1 due next week
   - create your Box folder
   - invite me and Genevieve
7. Fixed date error with class Thanksgiving week
8. What to do about missed class?
   - Use make-up day – but day before paper deadline
   - Schedule make-up class for presentations
   - Drop class on presenting causal results

Today

1. General problem of selection
2. Omitted variable bias in terms of regression coefficients
3. Indicator variables
4. Discussion of Black et al

1. General Problem of Selection Bias

The General Problem

If we assume a homogeneous treatment effect, κ, then

$$\text{Avg}_n[Y_{1i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0] \quad =$$

The General Problem

If we assume a homogeneous treatment effect, κ, then

$$\begin{aligned} \text{Avg}_n[Y_{1i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0] &= \\ \text{Avg}_n[\kappa + Y_{0i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0] &= \end{aligned}$$

The General Problem

If we assume a homogeneous treatment effect, κ, then

$$
\begin{aligned}
\text{Avg}_n[Y_{1i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0] &= \\
\text{Avg}_n[\kappa + Y_{0i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0] &= \\
\kappa + \text{Avg}_n[Y_{0i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0]
\end{aligned}
$$

The General Problem

If we assume a homogeneous treatment effect, κ, then

$$\begin{aligned} \text{Avg}_n[Y_{1i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0] &= \\ \text{Avg}_n[\kappa + Y_{0i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0] &= \\ \kappa + \text{Avg}_n[Y_{0i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0] & \end{aligned}$$

Red term is difference in outcome Y for treated relative to untreated in the absence of treatment: **selection bias**.

Let's Think of Some Examples of Selection Bias

$$\text{Avg}_n[Y_{0i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0]$$

Let's Think of Some Examples of Selection Bias

$$\text{Avg}_n[Y_{0i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0]$$

A fix: control for covariates X_i to make selection bias disappear.

Let's Think of Some Examples of Selection Bias

$$\text{Avg}_n[Y_{0i}|D_i = 1] - \text{Avg}_n[Y_{0i}|D_i = 0]$$

A fix: control for covariates X_i to make selection bias disappear.

Strong evidence that "controlling for observables" rarely gets rid of selection.

2. Omitted Variable Bias Formula

Long (True) vs. Short (False) Regression

Suppose that the “true” (long) regression is

$$Y = \alpha + \beta^l X_1 + \gamma X_2 + \epsilon^l$$

Long (True) vs. Short (False) Regression

Suppose that the "true" (long) regression is

$$Y = \alpha + \beta^l X_1 + \gamma X_2 + \epsilon^l$$

Unfortunately, you don't observe X_2 – examples?

Long (True) vs. Short (False) Regression

Suppose that the "true" (long) regression is

$$Y = \alpha + \beta^l X_1 + \gamma X_2 + \epsilon^l$$

Unfortunately, you don't observe X_2 – examples?

So instead you estimate the "false" (short) regression

$$Y = \alpha + \beta^s X_1 + \epsilon^s$$

Should you trust β^s?

Evaluating Whether to Trust β^s

Recall

$$Y = \alpha + \beta^l X_1 + \gamma X_2 + \epsilon^l \quad (1)$$

$$Y = \alpha + \beta^s X_1 + \epsilon^s \quad (2)$$

Evaluating Whether to Trust β^s

Recall

$$Y = \alpha + \beta^l X_1 + \gamma X_2 + \epsilon^l \quad (1)$$

$$Y = \alpha + \beta^s X_1 + \epsilon^s \quad (2)$$

Estimate the relationship between the treatment X_1 and the omitted variable X_2:

$$X_1 = \pi_0 + \pi_1 X_2 + \epsilon^c$$

Evaluating Whether to Trust β^s

Recall

$$Y = \alpha + \beta^l X_1 + \gamma X_2 + \epsilon^l \quad (1)$$

$$Y = \alpha + \beta^s X_1 + \epsilon^s \quad (2)$$

Estimate the relationship between the treatment X_1 and the omitted variable X_2:

$$X_1 = \pi_0 + \pi_1 X_2 + \epsilon^c$$

Then (proof in book)

$$\text{OVB} =$$

Evaluating Whether to Trust β^s

Recall

$$Y = \alpha + \beta^l X_1 + \gamma X_2 + \epsilon^l \quad (1)$$

$$Y = \alpha + \beta^s X_1 + \epsilon^s \quad (2)$$

Estimate the relationship between the treatment X_1 and the omitted variable X_2:

$$X_1 = \pi_0 + \pi_1 X_2 + \epsilon^c$$

Then (proof in book)

$$\text{OVB} = \beta^s - \beta^l$$

Evaluating Whether to Trust β^s

Recall

$$Y = \alpha + \beta^l X_1 + \gamma X_2 + \epsilon^l \tag{1}$$

$$Y = \alpha + \beta^s X_1 + \epsilon^s \tag{2}$$

Estimate the relationship between the treatment X_1 and the omitted variable X_2:

$$X_1 = \pi_0 + \pi_1 X_2 + \epsilon^c$$

Then (proof in book)

$$\text{OVB} = \beta^s - \beta^l = \pi_1 \gamma$$

Evaluating Whether to Trust β^s

Recall

$$Y = \alpha + \beta^l X_1 + \gamma X_2 + \epsilon^l \tag{1}$$

$$Y = \alpha + \beta^s X_1 + \epsilon^s \tag{2}$$

Estimate the relationship between the treatment X_1 and the omitted variable X_2:

$$X_1 = \pi_0 + \pi_1 X_2 + \epsilon^c$$

Then (proof in book)

$$\text{OVB} = \beta^s - \beta^l = \pi_1 \gamma$$

OVB is one type of selection bias.

Let's think about this equation

$\pi_1 \equiv$ relationship between X_1 and X_2
$\gamma \equiv$ relationship between X_2 and Y in long regression

$$\text{OVB} = \beta^s - \beta^l = \pi_1 \gamma$$

- What if the treatment and the omitted variable are not correlated?

Let's think about this equation

$\pi_1 \equiv$ relationship between X_1 and X_2
$\gamma \equiv$ relationship between X_2 and Y in long regression

$$\text{OVB} = \beta^s - \beta^l = \pi_1 \gamma$$

- What if the treatment and the omitted variable are not correlated?
- What if the omitted variable is not correlated with the outcome Y?

Let's think about this equation

$\pi_1 \equiv$ relationship between X_1 and X_2
$\gamma \equiv$ relationship between X_2 and Y in long regression

$$\text{OVB} = \beta^s - \beta^l = \pi_1 \gamma$$

- What if the treatment and the omitted variable are not correlated?
- What if the omitted variable is not correlated with the outcome Y?
- Any story about omitted variable bias needs to include **both** parts

Let's think about this equation

$\pi_1 \equiv$ relationship between X_1 and X_2
$\gamma \equiv$ relationship between X_2 and Y in long regression

$$\text{OVB} = \beta^s - \beta^l = \pi_1 \gamma$$

- What if the treatment and the omitted variable are not correlated?
- What if the omitted variable is not correlated with the outcome Y?
- Any story about omitted variable bias needs to include **both** parts
- Resolving the problem of omitted variable bias in order to generate causal estimates is the key concern of this course

3. Indicator Variables

What is an indicator variable?

All these things are the same

- dummy variable
- indicator variable
- fixed effect
- $1\{\text{condition}\}$

What is an indicator variable?

All these things are the same

- dummy variable
- indicator variable
- fixed effect
- $1\{\text{condition}\}$

All are coded 1 if true and 0 otherwise

Interpreting Indicator Variables

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

- female $\in \{0, 1\}$
- how do we interpret β_1?

Interpreting Indicator Variables

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

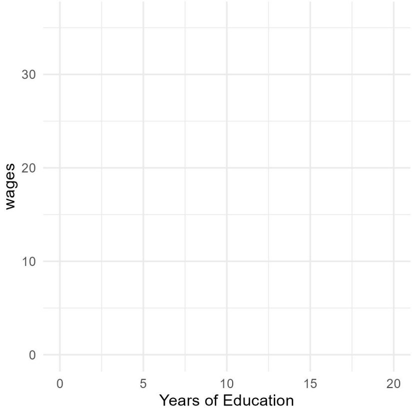
- $\text{female} \in \{0, 1\}$
- how do we interpret β_1?
- let's draw in a figure

Interpreting Coefficients

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

Draw the relationship

- x axis is education
- y axis is wage
- where is β_0?

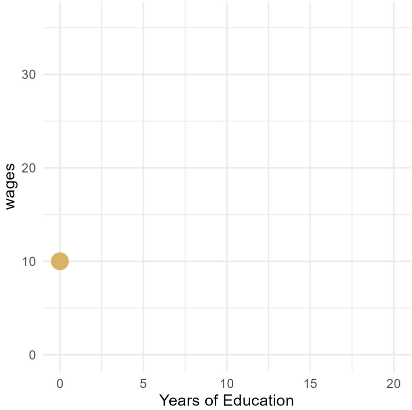


Interpreting Coefficients

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

Draw the relationship

- x axis is education
- y axis is wage
- where is β_0?

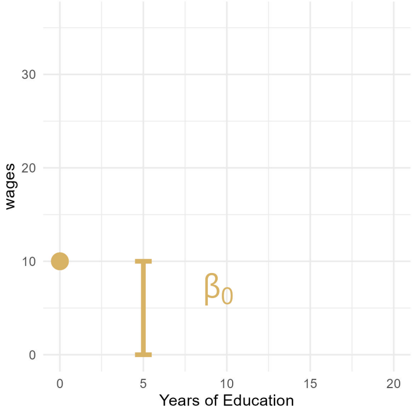


Interpreting Coefficients

$$\text{wage} = \beta_0 + \beta_1\text{female} + \beta_2\text{education} + \epsilon$$

Draw the relationship

- x axis is education
- y axis is wage
- where is β_0?

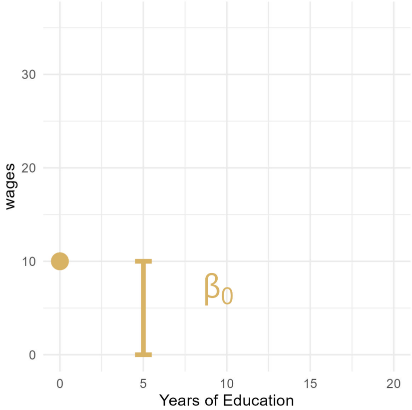


Interpreting Coefficients

$$\text{wage} = \beta_0 + \beta_1\text{female} + \beta_2\text{education} + \epsilon$$

Draw the relationship

- x axis is education
- y axis is wage
- where is β_0?
- where is β_2?

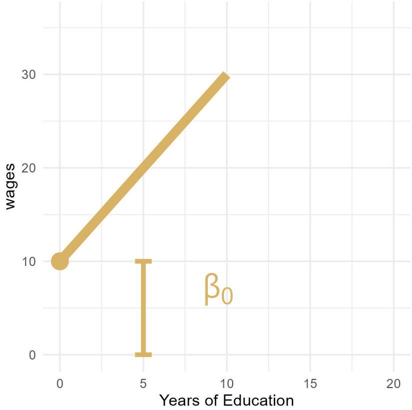


Interpreting Coefficients

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

Draw the relationship

- x axis is education
- y axis is wage
- where is β_0?
- where is β_2?



Interpreting Coefficients

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

Draw the relationship

- x axis is education
- y axis is wage
- where is β_0?
- where is β_2?

Interpreting Coefficients

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

Draw the relationship

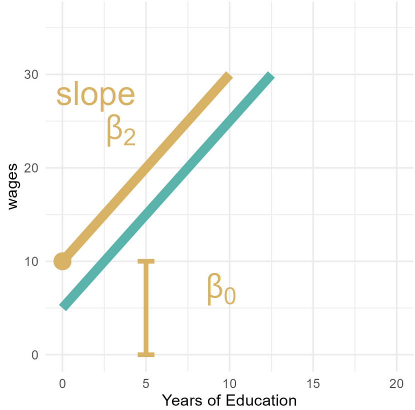
- x axis is education
- y axis is wage
- where is β_0?
- where is β_2?
- how do we draw wages for women as a function of education?

Interpreting Coefficients

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

Draw the relationship

- x axis is education
- y axis is wage
- where is β_0?
- where is β_2?
- how do we draw wages for women as a function of education?
  $\beta_2 * \text{education} + \beta_1$

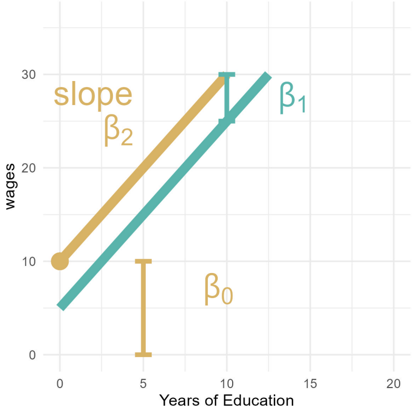


Interpreting Coefficients

$$\text{wage} = \beta_0 + \beta_1\text{female} + \beta_2\text{education} + \epsilon$$

Draw the relationship

- x axis is education
- y axis is wage
- where is β_0?
- where is β_2?
- how do we draw wages for women as a function of education?
  $\beta_2 * \text{education} + \beta_1$



Coding Variables

- Suppose we want to look at the effect of gender on wages:

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

- Data are coded 1 for men, 2 for women
- Why don't we just use this coding? Why do we make a dummy variable?

Coding Variables

- Suppose we want to look at the effect of gender on wages:

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

- Data are coded 1 for men, 2 for women
- Why don't we just use this coding? Why do we make a dummy variable?
- Why do we not make one dummy variable for each gender?

Coding Variables

- Suppose we want to look at the effect of gender on wages:

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

- Data are coded 1 for men, 2 for women
- Why don't we just use this coding? Why do we make a dummy variable?
- Why do we not make one dummy variable for each gender?
- How can you modify the specification to allow education to have differential impacts by gender?

Coding Variables

- Suppose we want to look at the effect of gender on wages:

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \epsilon$$

- Data are coded 1 for men, 2 for women
- Why don't we just use this coding? Why do we make a dummy variable?
- Why do we not make one dummy variable for each gender?
- How can you modify the specification to allow education to have differential impacts by gender?

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \beta_3 \text{female} * \text{education} + \epsilon$$

Interpreting Indicator Variables in Interaction

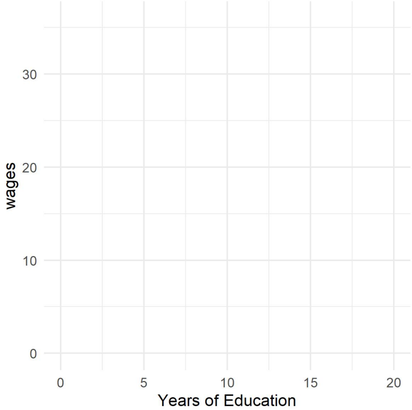
$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \beta_3 \text{female} * \text{education} + \epsilon$$

- female $\in \{0, 1\}$
- what is this specification doing differently?

Interpreting Coefficients in Interacted Specification

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \beta_3 \text{female} * \text{education} + \epsilon$$

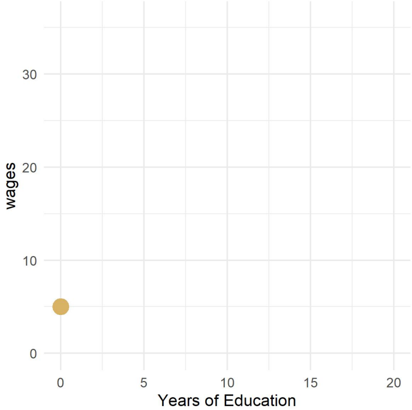
- what are men's wages with no education?



Interpreting Coefficients in Interacted Specification

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \beta_3 \text{female} * \text{education} + \epsilon$$

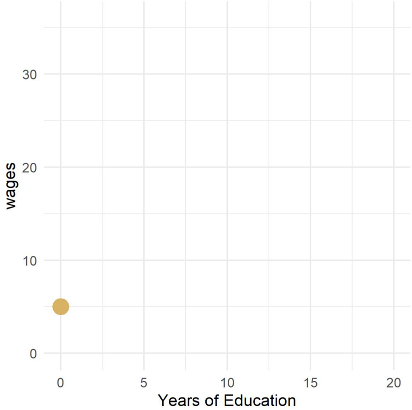
- what are men's wages with no education? β_0



Interpreting Coefficients in Interacted Specification

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \beta_3 \text{female} * \text{education} + \epsilon$$

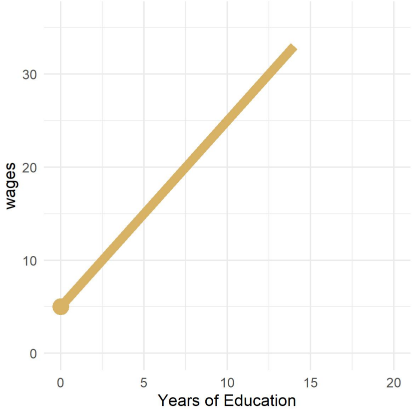
- what are men's wages with no education? β_0
- how do men's wages change with education?



Interpreting Coefficients in Interacted Specification

$$wage = \beta_0 + \beta_1 female + \beta_2 education + \beta_3 female * education + \epsilon$$

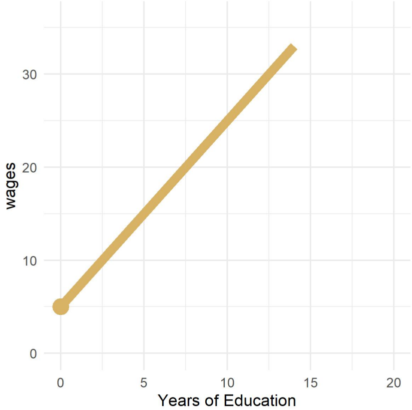
- what are men's wages with no education? β_0
- how do men's wages change with education? $\beta_2 * education$



Interpreting Coefficients in Interacted Specification

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \beta_3 \text{female} * \text{education} + \epsilon$$

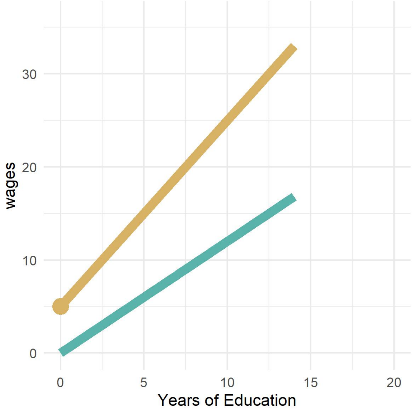
- what are men's wages with no education? β_0
- how do men's wages change with education? $\beta_2 * \text{education}$
- how do women's wages change with education?



Interpreting Coefficients in Interacted Specification

$$\text{wage} = \beta_0 + \beta_1\text{female} + \beta_2\text{education} + \beta_3\text{female} * \text{education} + \epsilon$$

- what are men's wages with no education? β_0
- how do men's wages change with education? $\beta_2 * \text{education}$
- how do women's wages change with education?
  start at $\beta_0 - \beta_1$
  change by
  $\beta_2 * \text{education} + \beta_3 * \text{education}$



Formal Testing

$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \beta_3 \text{female} * \text{education} + \epsilon$$

- How to test whether education has a differential effect on women's wages relative to men's?

Formal Testing

$$\text{wage} = \beta_0 + \beta_1\text{female} + \beta_2\text{education} + \beta_3\text{female} * \text{education} + \epsilon$$

- How to test whether education has a differential effect on women's wages relative to men's?
- Test $\beta_3 = 0$

4. Black et al on family size

Paper Overview

What is this paper about?

- what is the theory that they rebut in this paper?

Paper Overview

What is this paper about?

- what is the theory that they rebut in this paper? Becker's theory about quality vs. quantity in kids
- to whom is it due?

Paper Overview

What is this paper about?

- what is the theory that they rebut in this paper? Becker's theory about quality vs. quantity in kids
- to whom is it due? Nobel laureate Becker and some buddies

Paper Overview

What are the data?

What is this paper about?

- what is the theory that they rebut in this paper? Becker's theory about quality vs. quantity in kids
- to whom is it due? Nobel laureate Becker and some buddies

Paper Overview

What is this paper about?

- what is the theory that they rebut in this paper? Becker's theory about quality vs. quantity in kids
- to whom is it due? Nobel laureate Becker and some buddies

What are the data?

- people aged 16-74 from 1986-2000 (would you be in this sample?)
- parents and kids must both appear in the dataset
- can match parents to kids
- about each person they know year of birth, completed education, earnings
- about each family, they know family size

Paper Overview

What is this paper about?

- what is the theory that they rebut in this paper? Becker's theory about quality vs. quantity in kids
- to whom is it due? Nobel laureate Becker and some buddies

What are the data?

- people aged 16-74 from 1986-2000 (would you be in this sample?)
- parents and kids must both appear in the dataset
- can match parents to kids
- about each person they know year of birth, completed education, earnings
- about each family, they know family size
- what is the unit of observation?

What Can We Learn from Summary Statistics?

TABLE III
AVERAGE EDUCATION BY NUMBER OF CHILDREN IN FAMILY AND BIRTH ORDER

	Average education	Average mother's education	Average father's education	Fraction with <12 years	Fraction with 12 years	Fraction with >12 years
			Family size			
1	12.0	9.2	10.1	.44	.25	.31
2	12.4	9.9	10.8	.34	.31	.35
3	12.3	9.7	10.6	.37	.30	.33
4	12.0	9.3	10.1	.43	.29	.28
5	11.7	8.8	9.5	.49	.27	.24
6	11.4	8.5	9.1	.54	.25	.20
7	11.2	8.3	8.9	.57	.24	.19
8	11.1	8.2	8.8	.58	.24	.18
9	11.0	8.0	8.6	.59	.25	.16
10+	11.0	7.9	8.8	.59	.26	.15
			Birth order			
1	12.2	9.7	10.6	.38	.28	.34
2	12.2	9.6	10.5	.38	.30	.31
3	12.0	9.3	10.2	.40	.31	.29
4	11.9	9.0	9.7	.43	.32	.25
5	11.7	8.6	9.2	.46	.31	.22
6	11.6	8.3	8.9	.49	.31	.20
7	11.5	8.1	8.7	.51	.30	.19
8	11.6	8.0	8.6	.49	.31	.20
9	11.3	7.9	8.4	.53	.32	.15
10+	11.3	7.8	8.7	.52	.32	.15
			All			
	12.2	9.5	10.4	.39	.29	.32

- We ignore instrumental variables and twins
- Focus only on the regular estimations
- But start with summary stats
- What does Table 3 tell us about education as family size increases?

What Can We Learn from Summary Statistics?

TABLE III
AVERAGE EDUCATION BY NUMBER OF CHILDREN IN FAMILY AND BIRTH ORDER

	Average education	Average mother's education	Average father's education	Fraction with <12 years	Fraction with 12 years	Fraction with >12 years
			Family size			
1	12.0	9.2	10.1	.44	.25	.31
2	12.4	9.9	10.8	.34	.31	.35
3	12.3	9.7	10.6	.37	.30	.33
4	12.0	9.3	10.1	.43	.29	.28
5	11.7	8.8	9.5	.49	.27	.24
6	11.4	8.5	9.1	.54	.25	.20
7	11.2	8.3	8.9	.57	.24	.19
8	11.1	8.2	8.8	.58	.24	.18
9	11.0	8.0	8.6	.59	.25	.16
10+	11.0	7.9	8.8	.59	.26	.15
			Birth order			
1	12.2	9.7	10.6	.38	.28	.34
2	12.2	9.6	10.5	.38	.30	.31
3	12.0	9.3	10.2	.40	.31	.29
4	11.9	9.0	9.7	.43	.32	.25
5	11.7	8.6	9.2	.46	.31	.22
6	11.6	8.3	8.9	.49	.31	.20
7	11.5	8.1	8.7	.51	.30	.19
8	11.6	8.0	8.6	.49	.31	.20
9	11.3	7.9	8.4	.53	.32	.15
10+	11.3	7.8	8.7	.52	.32	.15
			All			
	12.2	9.5	10.4	.39	.29	.32

- We ignore instrumental variables and twins
- Focus only on the regular estimations
- But start with summary stats
- What does Table 3 tell us about education as family size increases? increases (for 1 to 2), then declines
- What does Table 3 tell us about education as birth order increases?

What Can We Learn from Summary Statistics?

TABLE III
AVERAGE EDUCATION BY NUMBER OF CHILDREN IN FAMILY AND BIRTH ORDER

	Average education	Average mother's education	Average father's education	Fraction with <12 years	Fraction with 12 years	Fraction with >12 years
			Family size			
1	12.0	9.2	10.1	.44	.25	.31
2	12.4	9.9	10.8	.34	.31	.35
3	12.3	9.7	10.6	.37	.30	.33
4	12.0	9.3	10.1	.43	.29	.28
5	11.7	8.8	9.5	.49	.27	.24
6	11.4	8.5	9.1	.54	.25	.20
7	11.2	8.3	8.9	.57	.24	.19
8	11.1	8.2	8.8	.58	.24	.18
9	11.0	8.0	8.6	.59	.25	.16
10+	11.0	7.9	8.8	.59	.26	.15
			Birth order			
1	12.2	9.7	10.6	.38	.28	.34
2	12.2	9.6	10.5	.38	.30	.31
3	12.0	9.3	10.2	.40	.31	.29
4	11.9	9.0	9.7	.43	.32	.25
5	11.7	8.6	9.2	.46	.31	.22
6	11.6	8.3	8.9	.49	.31	.20
7	11.5	8.1	8.7	.51	.30	.19
8	11.6	8.0	8.6	.49	.31	.20
9	11.3	7.9	8.4	.53	.32	.15
10+	11.3	7.8	8.7	.52	.32	.15
			All			
	12.2	9.5	10.4	.39	.29	.32

- We ignore instrumental variables and twins
- Focus only on the regular estimations
- But start with summary stats
- What does Table 3 tell us about education as family size increases? increases (for 1 to 2), then declines
- What does Table 3 tell us about education as birth order increases? declines
- Give an example of a potential omitted variable for this research question

Make a Class Dataset

- Get four families as an example to match paper
- What info do we need?

Make a Class Dataset

- Get four families as an example to match paper
- What info do we need?
    - year of birth of each sibling
    - education of each family member

Make a Class Dataset

- Get four families as an example to match paper
- What info do we need?
  - year of birth of each sibling
  - education of each family member
- Make this into a dataset you could do the sort of regressions that Black et al did.
- Make a copy of the google sheet I sent and enter data there
- Some hints
  - What's the unit of observation?

Make a Class Dataset

- Get four families as an example to match paper
- What info do we need?
  - year of birth of each sibling
  - education of each family member
- Make this into a dataset you could do the sort of regressions that Black et al did.
- Make a copy of the google sheet I sent and enter data there
- Some hints
  - What's the unit of observation? person
  - What variables do you need?

Make a Class Dataset

- Get four families as an example to match paper
- What info do we need?
  - year of birth of each sibling
  - education of each family member
- Make this into a dataset you could do the sort of regressions that Black et al did.
- Make a copy of the google sheet I sent and enter data there
- Some hints
  - What's the unit of observation? person
  - What variables do you need?
    - you need to be able to know who is in the same family
    - you need a variable for birth order
    - you need a variable for family size

Understanding Main Estimates: Table 4

What's the estimating equation for Table 4 column 1? (read p. 678, pp under 3.A.)

Understanding Main Estimates: Table 4

What's the estimating equation for Table 4 column 1? (read p. 678, pp under 3.A.)

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{no. kids in fam}_f + \beta_2 \text{year of birth FE}_i + \epsilon_{i,f}$$

Modifying Dataset to Estimate

Estimating Column 1

- To estimate column 1, what additional variable does your dataset need?

Modifying Dataset to Estimate

Estimating Column 1

- To estimate column 1, what additional variable does your dataset need? birth year FE
- Why do we include year of birth fe?
- How do we interpret the coeff -0.182?

Modifying Dataset to Estimate

Estimating Column 1

- To estimate column 1, what additional variable does your dataset need?
  birth year FE
- Why do we include year of birth fe?
- How do we interpret the coeff -0.182?
  increasing a family by one more child decreases the average child's education by .18 of a year (20% of a year)

Estimating Column 2 – New regression equation?

Modifying Dataset to Estimate

Estimating Column 1

- To estimate column 1, what additional variable does your dataset need?
  birth year FE
- Why do we include year of birth fe?
- How do we interpret the coeff -0.182?
  increasing a family by one more child decreases the average child's education by .18 of a year (20% of a year)

Estimating Column 2 – New regression equation?

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{kids in fam FE}_f + \beta_2 \text{year of birth FE}_i + \epsilon_{i,f}$$

Modifying Dataset to Estimate

Estimating Column 1

- To estimate column 1, what additional variable does your dataset need?
  birth year FE
- Why do we include year of birth fe?
- How do we interpret the coeff -0.182?
  increasing a family by one more child decreases the average child's education by .18 of a year (20% of a year)

Estimating Column 2 – New regression equation?

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{kids in fam FE}_f + \beta_2 \text{year of birth FE}_i + \epsilon_{i,f}$$

- what does our dataset need to estimate it?

Modifying Dataset to Estimate

Estimating Column 1

- To estimate column 1, what additional variable does your dataset need?
  birth year FE
- Why do we include year of birth fe?
- How do we interpret the coeff -0.182?
  increasing a family by one more child decreases the average child's education by .18 of a year (20% of a year)

Estimating Column 2 – New regression equation?

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{kids in fam FE}_f + \beta_2 \text{year of birth FE}_i + \epsilon_{i,f}$$

- what does our dataset need to estimate it?
- how do we interpret 0.272?

Table 4: Columns 3 and 4

Eq for Table 4, Column 3:

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{no. kids in fam}_f + \beta_2 \text{year of birth FE}_i + \beta_3 X_{i,f} + \epsilon_{i,f}$$

- Add controls. Any questions about how they do that?

Table 4: Columns 3 and 4

Eq for Table 4, Column 3:

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{no. kids in fam}_f + \beta_2 \text{year of birth FE}_i + \beta_3 X_{i,f} + \epsilon_{i,f}$$

- Add controls. Any questions about how they do that?
- What do we learn by comparing columns 3 and 4 to 1 and 2?

Table 4: Columns 3 and 4

Eq for Table 4, Column 3:

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{no. kids in fam}_f + \beta_2 \text{year of birth FE}_i + \beta_3 X_{i,f} + \epsilon_{i,f}$$

- Add controls. Any questions about how they do that?
- What do we learn by comparing columns 3 and 4 to 1 and 2?
- Controls are important, but they don't account for the entire effect

Table 4: Columns 5 and 6

- Column 5
  - what is the regression equation?

Table 4: Columns 5 and 6

- Column 5
  - what is the regression equation?

    $$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{no. kids in fam}_f + \beta_2 \text{year of birth FE}_i + \beta_3 X_{i,f} + \beta_4 \text{birth order FE}_i + \epsilon_{i,f}$$

  - fix your dataset to have enough variables to estimate this
  - how do we interpret these coefficients?

Table 4: Columns 5 and 6

- Column 5
  - what is the regression equation?

    $$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{no. kids in fam}_f + \beta_2 \text{year of birth FE}_i + \beta_3 X_{i,f} + \beta_4 \text{birth order FE}_i + \epsilon_{i,f}$$

  - fix your dataset to have enough variables to estimate this
  - how do we interpret these coefficients?
- then column 6
  - what is the regression equation?

Table 4: Columns 5 and 6

- Column 5
  - what is the regression equation?

    $$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{no. kids in fam}_f + \beta_2 \text{year of birth FE}_i + \beta_3 X_{i,f} + \beta_4 \text{birth order FE}_i + \epsilon_{i,f}$$

  - fix your dataset to have enough variables to estimate this
  - how do we interpret these coefficients?
- then column 6
  - what is the regression equation?

    $$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{kids in fam FE}_f + \beta_2 \text{year of birth FE}_i + \beta_3 X_{i,f} + \beta_4 \text{birth order FE}_i + \epsilon_{i,f}$$

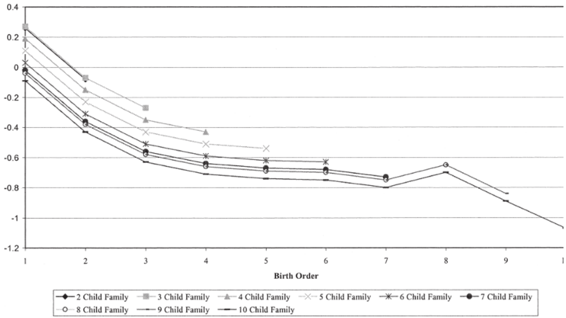
  - fix your dataset so that you have enough variables to estimate this

Visual Representation of Findings

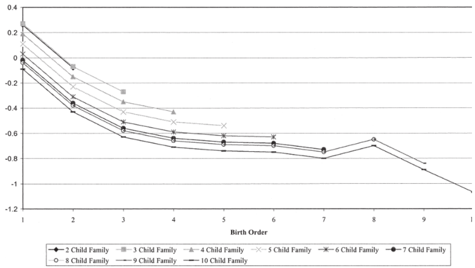
- How does this translate to figure 1 (p. 689)?
- Or, what are they plotting there and what does it mean?
  - warning: the note is not correct – it says predicted values, but these are coefficients

Visual Representation of Findings

- How does this translate to figure 1 (p. 689)?
- Or, what are they plotting there and what does it mean?
  - warning: the note is not correct – it says predicted values, but these are coefficients

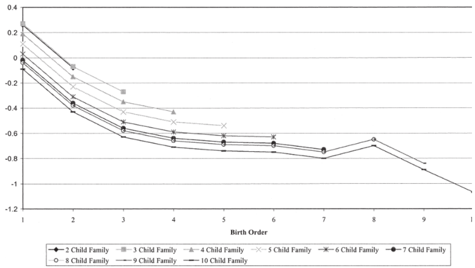


Making the Figure



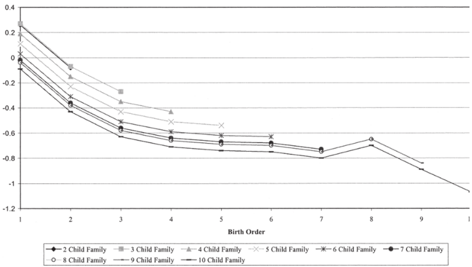
- no info for family size $= 1$

Making the Figure



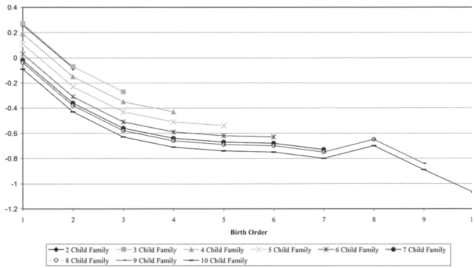
- no info for family size $= 1$
- for family size of 2, first born is

Making the Figure



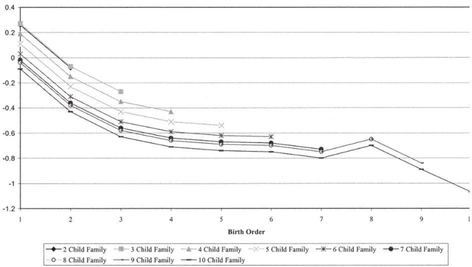
- no info for family size $= 1$
- for family size of 2, first born is 0.257, second born is

Making the Figure



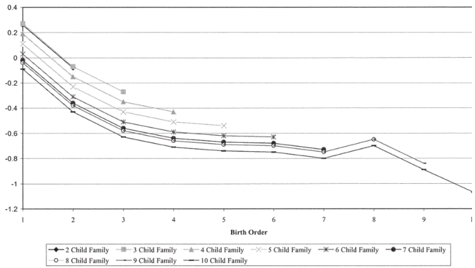
- no info for family size = 1
- for family size of 2, first born is 0.257, second born is 0.257-0.342

Making the Figure



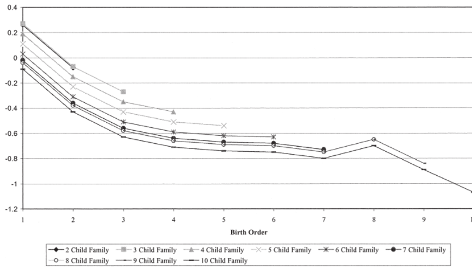
- no info for family size = 1
- for family size of 2, first born is 0.257, second born is 0.257-0.342
- for family size of 3, first born is

Making the Figure



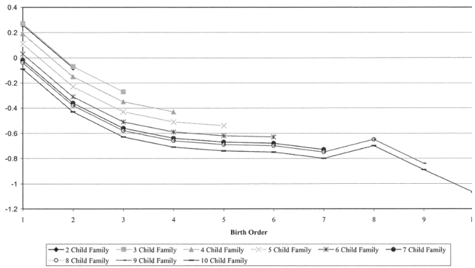
- no info for family size = 1
- for family size of 2, first born is 0.257, second born is 0.257-0.342
- for family size of 3, first born is 0.270, second born is

Making the Figure



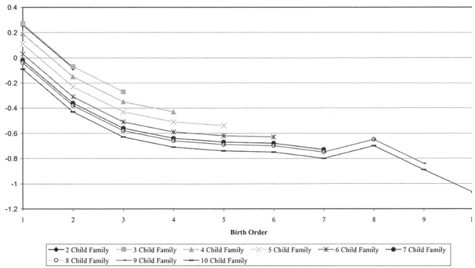
- no info for family size $= 1$
- for family size of 2, first born is 0.257, second born is 0.257-0.342
- for family size of 3, first born is 0.270, second born is 0.270-0.342, third born is

Making the Figure



- no info for family size = 1
- for family size of 2, first born is 0.257, second born is 0.257-0.342
- for family size of 3, first born is 0.270, second born is 0.270-0.342, third born is 0.270-0.538

Making the Figure



- no info for family size $= 1$
- for family size of 2, first born is 0.257, second born is 0.257-0.342
- for family size of 3, first born is 0.270, second born is 0.270-0.342, third born is 0.270-0.538
- why are the lines in the figure parallel?

Understanding Table 6

- what's the estimating eqn for table 6, col 1 (p 687)?

Understanding Table 6

- what's the estimating eqn for table 6, col 1 (p 687)?

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{year of birth dum}_i + \beta_2 X_i + \beta_3 \{1 \text{ if child } 2\}_i + \epsilon_{i,f}$$

Understanding Table 6

- what's the estimating eqn for table 6, col 1 (p 687)?

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{year of birth dum}_i + \beta_2 X_i + \beta_3 \{1 \text{ if child } 2\}_i + \epsilon_{i,f}$$

- do you have the data for these?
- why are these different than the last column of Table 3?

Understanding Table 6

- what's the estimating eqn for table 6, col 1 (p 687)?

$$\text{educ}_{i,f} = \beta_0 + \beta_1 \text{year of birth dum}_i + \beta_2 X_i + \beta_3 \{1 \text{ if child } 2\}_i + \epsilon_{i,f}$$

- do you have the data for these?
- why are these different than the last column of Table 3?
- Because they allow the effect of birth order to vary by family size

Next Lecture

- Read *Causal Mixtape*, Chapter 9.1 and 9.2
- Read linked Milligan article, section 5 optional
- Due next week
  - One page proposal
- Next week handout – Problem Set 2, with two week work period