Lecture 2:
Fixed Effects

January 22, 2025

Course Administration

1. Any problems with summary assignments?
   - I aspire to grade these weekly
2. Any problems accessing recorded lecture?
3. Proposal due next week

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1. Any problems with summary assignments?
   - I aspire to grade these weekly
2. Any problems accessing recorded lecture?
3. Proposal due next week
4. Lab session at 8:10 tonight
6. Problem set 1 due next week
   - submit to ps 1 folder on Piazza as a private message
   - we'll write back with feedback
7. Anything else?

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

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

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

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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

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

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

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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

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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

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

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

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

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Then (proof in book)

$$\text{OVB} =$$

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

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

OVB is one type of selection bias.

Let's think about this equation

$\pi_1 \equiv$ relationship between X_2 and X_1
$\gamma \equiv$ 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?

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- 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
- $1\{\text{condition}\}$

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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

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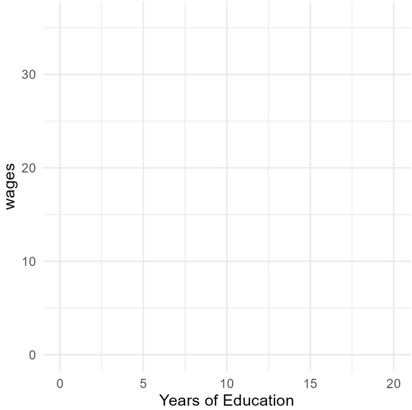
- female $\in \{0, 1\}$
- how do we interpret β_1?
- let's draw in a figure

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?



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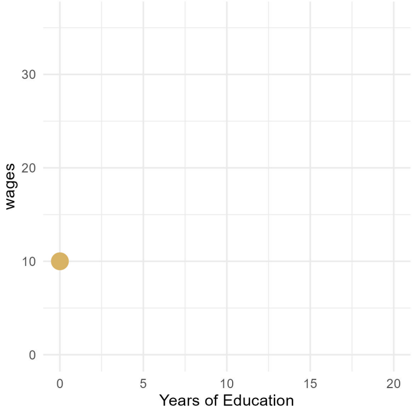

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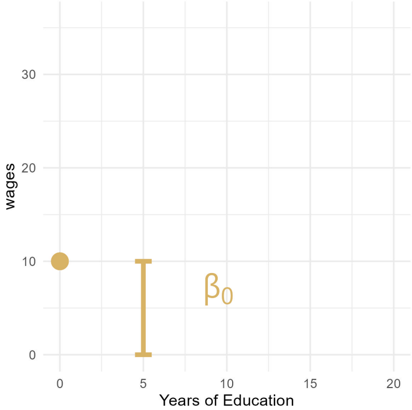

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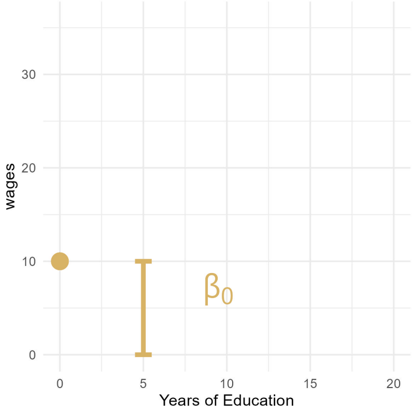

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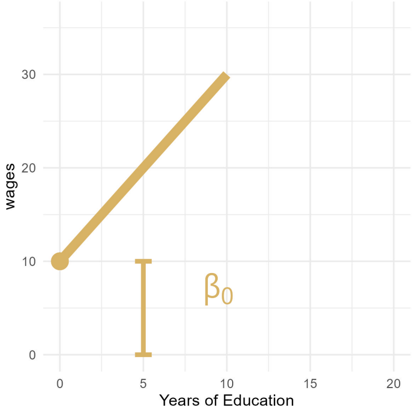

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- how do we draw wages for women as a function of education?

Interpreting Coefficients

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

Draw the relationship

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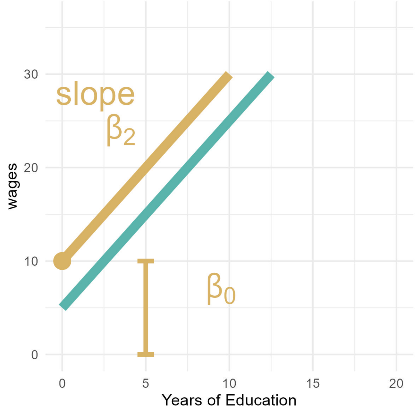
- how do we draw wages for women as a function of education? $\beta_2 * \text{education} + \beta_1$



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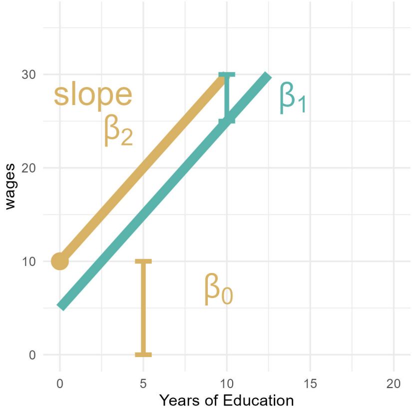

Coding Variables

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

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

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

Interpreting Indicator Variables in Interaction

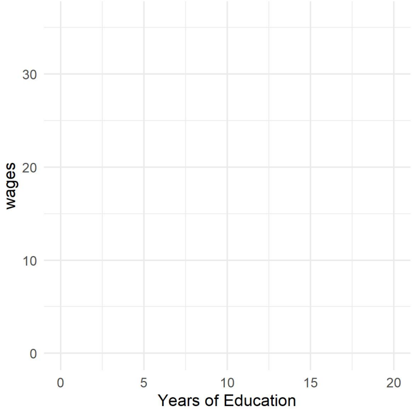
$$\text{wage} = \beta_0 + \beta_1 \text{female} + \beta_2 \text{education} + \beta_3 \text{female} * \text{education} + \epsilon$$

- $\text{female} \in \{0, 1\}$
- 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?



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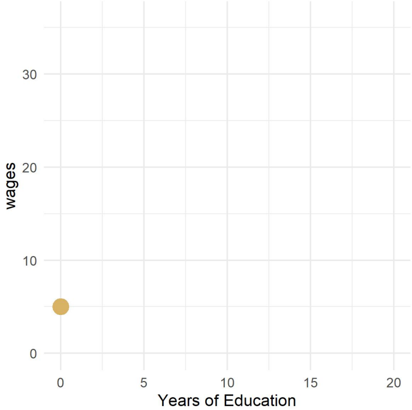

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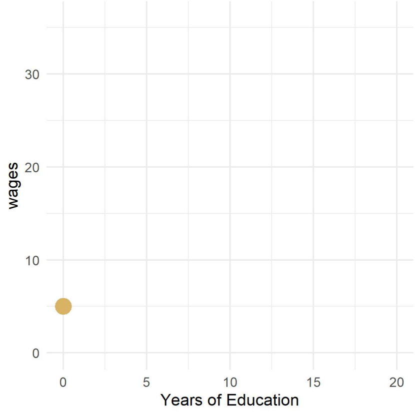
- what are men's wages with no education? β_0
- how do men's wages change with education?



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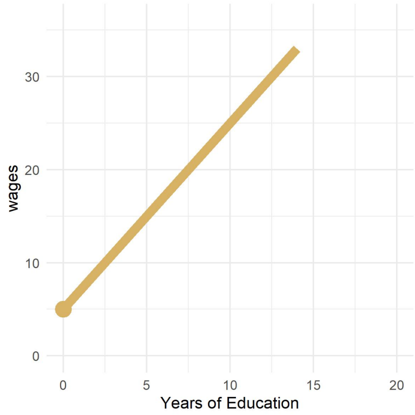
- what are men's wages with no education? β_0
- how do men's wages change with education? $\beta_2 * \text{education}$



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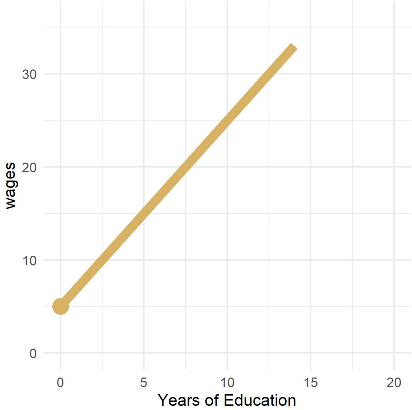
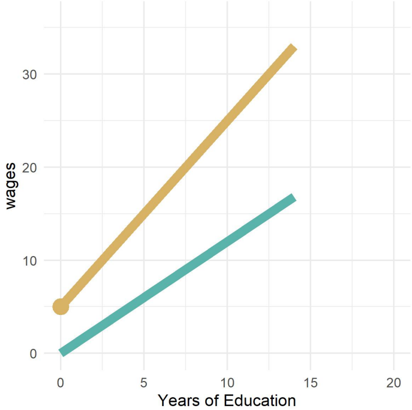
- what are men's wages with no education? β_0
- how do men's wages change with education? $\beta_2 * \text{education}$
- how do women's wages change with education?



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

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- 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?

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What are the data?

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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

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- 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?

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- What does Table 3 tell us about education as birth order increases?

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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 an omitted variable when studying the impact of family size on wages

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    - you need a variable for birth order
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Eq for Table 4, Column 3:

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- Controls are important, but they don't account for the entire effect

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Visual Representation of Findings

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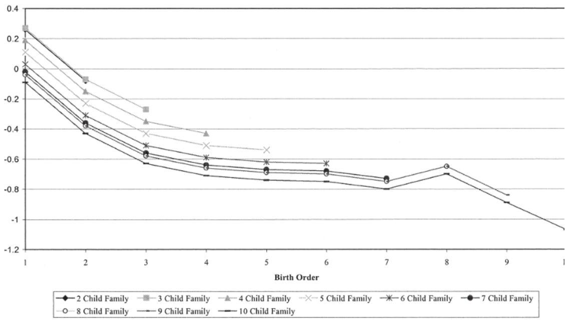

My Version: Visual Representation of Findings

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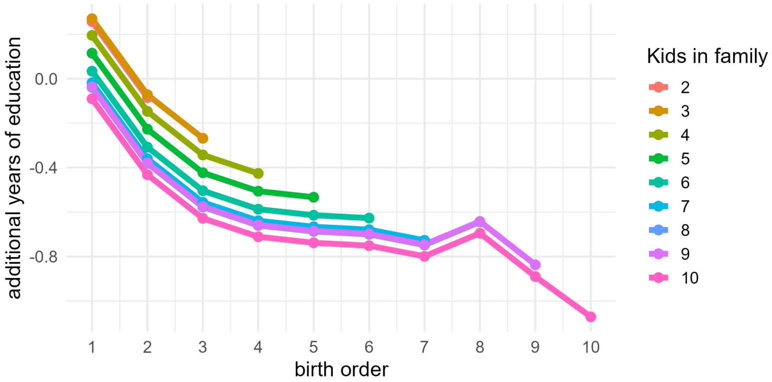

Making the Figure, Family Size = 2

- no info for family size = 1

Making the Figure, Family Size = 2

- no info for family size = 1
- family size of 2
  - first child?

Making the Figure, Family Size $= 2$

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  - second child?

Making the Figure, Family Size $= 2$

- no info for family size $=$ 1
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  - second child? 0.257-0.342

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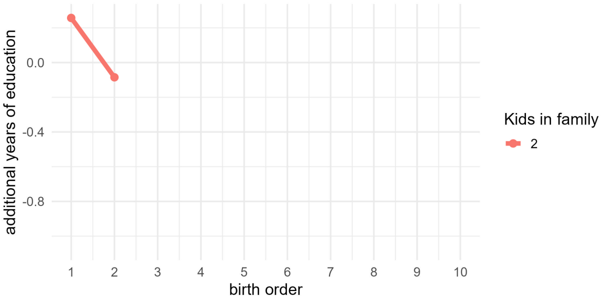

Making the Figure, Family Size $= 3$

- family size of 3
    - first child?

Making the Figure, Family Size $= 3$

- family size of 3
  - first child? 0.270

Making the Figure, Family Size = 3

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- family size of 3
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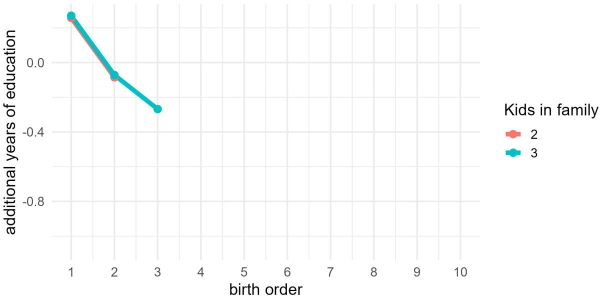
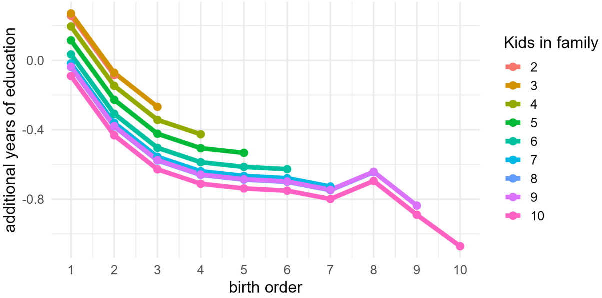
- why are the lines in the figure parallel?



Revisiting the Final Figure

- Which estimate would allow us to plot non-parallel lines?



Understanding Table 6

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

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- 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