Week 5: Threats to valid inferences 3

Measurement Error, Simultaneity and Reverse Causality

POLS0007
Principles of Social Science Research

University College London

1. Announcements
2. Last Week: Selection Bias and Omitted Variable Bias
3. Measurement Error
4. Simultaneity and Reverse Causality

Midterm Essay

- Midterm essay questions available on Moodle
- Exam has to be turned in by Monday, November 14th, no later than 2pm.
- Submission instructions on Moodle (read them carefully!), in the **General Documents** folder

Marking criteria

A (80-100) An essay which manifests all of the qualities expected of a first-class answer (see below) but to an exceptionally high degree. An essay which in addition demonstrates a notable degree of originality and individual flair.

A (70-79) An outstanding essay which shows a thorough knowledge of all the relevant material and an ability to deploy that knowledge in a relevant and focused manner. The essay shows clarity and precision of expression, structure and argument to a high degree. The essay also demonstrates a certain capacity to think independently of secondary sources and to make pertinent and persuasive use of examples.

B (60-69) An essay which shows good organisation of material and good textual knowledge and is clearly and concisely argued. It indicates a potential, at least, for independent critical thought, even if this may not be particularly profound or far-reaching.

C (50-59) An essay which shows a knowledge of the relevant material ranging from (at worst) patchy to (at best) sound. The essay indicates a satisfactory level of critical ability and draws sensible conclusions, but these conclusions may be somewhat naive or lacking in subtlety and are normally lacking in insight and originality. Overall this essay is sound and reasonably coherent, but limited and unimaginative.

D (40-49) An essay which demonstrates a basic awareness of the issues raised by the question and makes an occasionally successful attempt to frame a focused response, but the grasp of source materials is uncertain and the ability to develop a sustained critical argument rather limited. The material is, typically, poorly organized.

F (35-39) The grasp of what the question is asking is at best shaky, and the knowledge of source texts ranges from poor to non-existent. The argument is inconsistent or barely discernible and the structure deficient.

F (20-34) Muddled, rambling, irrelevant and ill-informed. An essay in this bracket is utterly devoid of critical awareness and quite fails to express, coherently, even the most basic argument.

Some tips

- You'll be given a text to analyze critically
- Your essay will answer a number of explicit questions
- There is not always ONE correct answer
- But there are many potentially incorrect answers
- Demonstrate a good grasp of the course material
- Be focused, avoid unnecessary text
- Use proper citation and referencing
- Polish the language
- Submit on time!

Recap: Selection Bias

- How do we select the sample/observations that we want to study?
- If we select the wrong ones we introduce a selection bias

- Selection on Y: typically underestimation of the causal effect
- Selection on X: typically no bias (but difficult to generalize the results)
- Self-selection (selection into treatment): the people in treatment and control group differ, can lead to bias either way
  - We need to think carefully about who is selected and in what way

Recap: Some terminology

- Independent variable, explanatory variable, X: these all mean the same thing. Something that causes variation in Y.
- A confounder is a variable Z that causes variation in X *and* Y. If it is not included in the analysis it will lead to bias.
- A confounder that is included in the analysis becomes a control variable and removes bias.
- A confounder that is not included in the analysis becomes an omitted variable and leads to bias.

Let's review omitted variable bias one more time. . .

Recap: Omitted Variable Bias

Effect of education (X) on earnings (Y)

Main effect		$X \rightarrow Y$			
Confounder (Z)	$Z \rightarrow X$		$Z \rightarrow Y$	Bias	Consequence
Ability		$\times$		$=$	Overestimate
Work experience		$\times$		$=$	Underestimate
Being a woman		$\times$		$=$	Underestimate
Poor health		$\times$		$=$	Overestimate

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Threats to Causal Inference

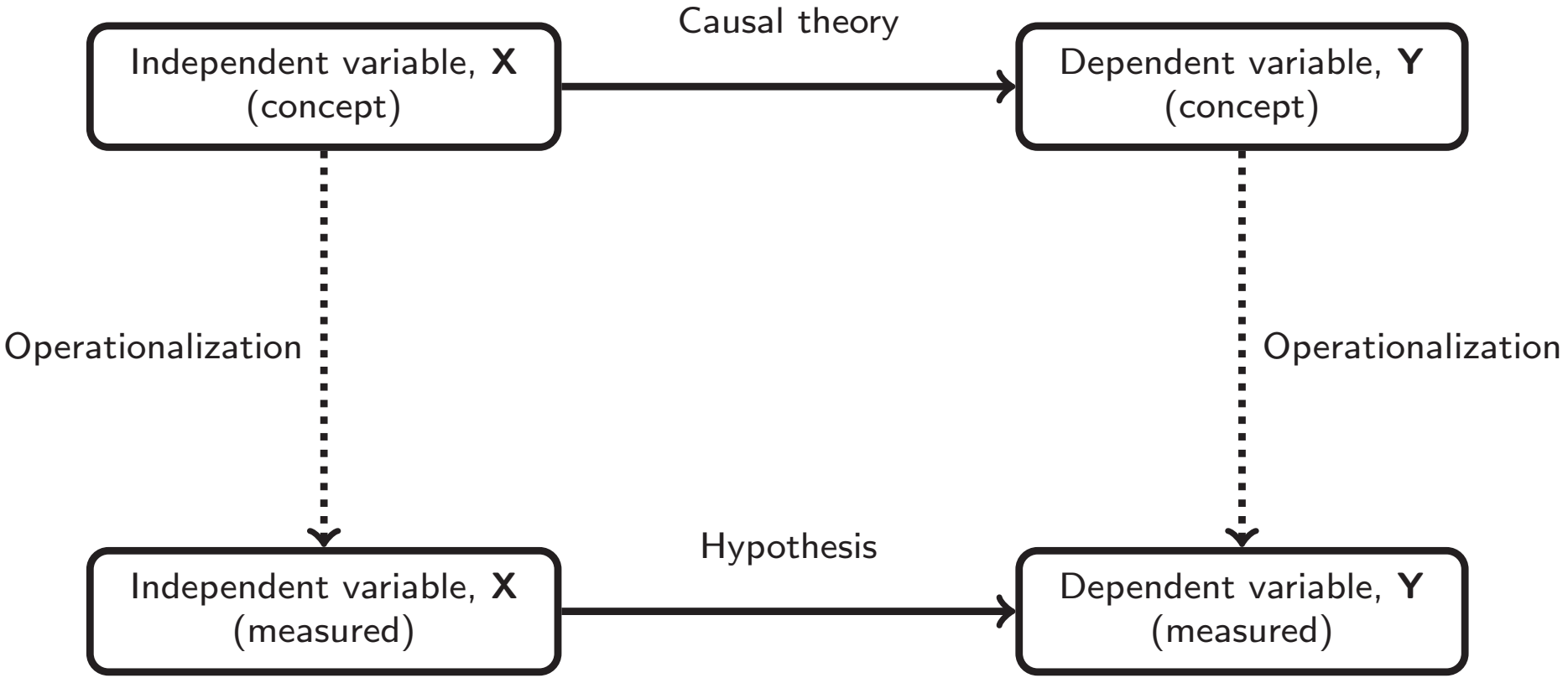
Problems with estimating the effect of X on Y:

- Threats to internal and external validity
- Selection bias
- Omitted variable bias

Today

- Measurement error
- Simultaneity and reverse causality

Remember this?



Measurement error

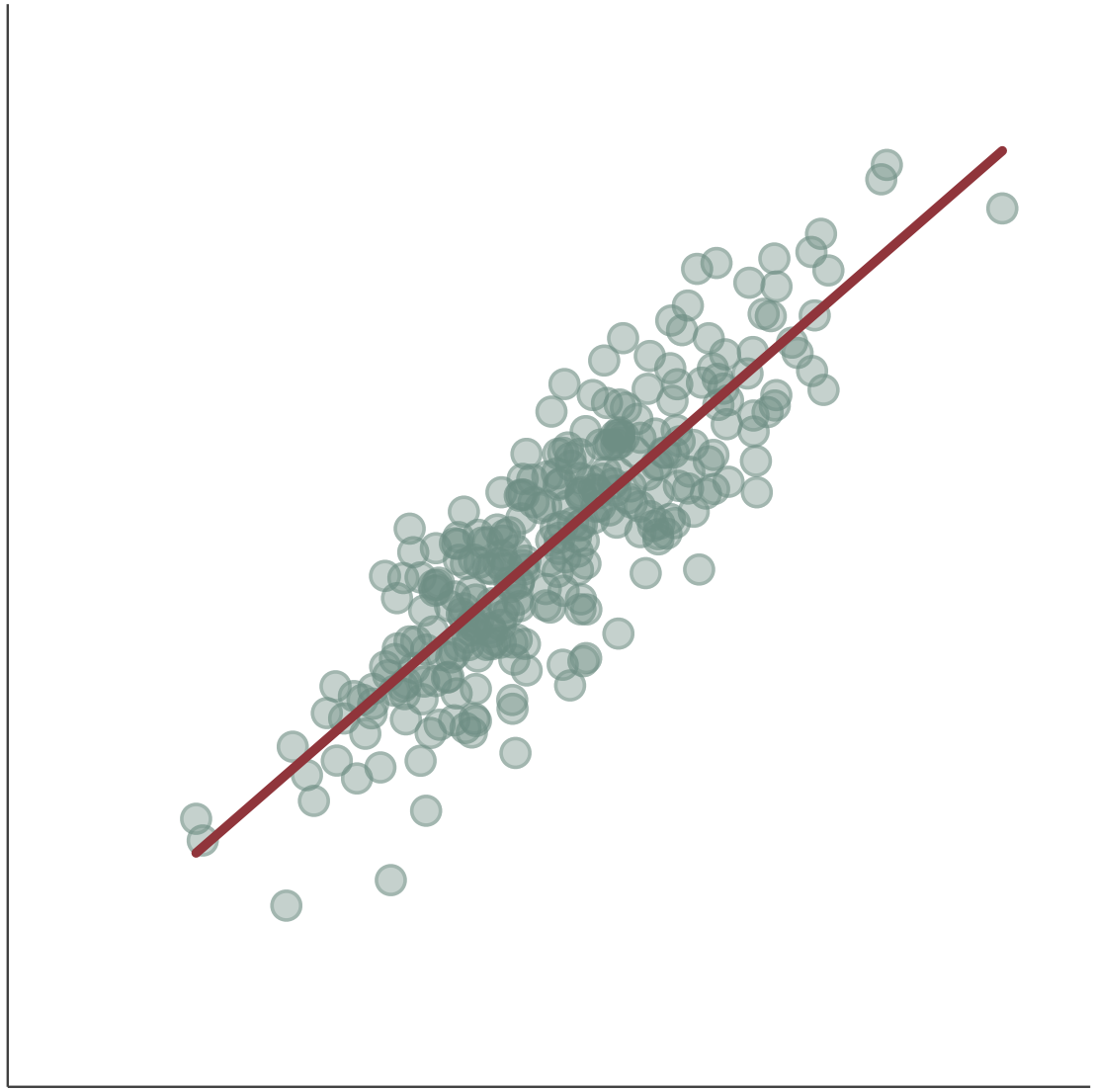
In operationalizing a hypothesis we go from concept to measurements

Often, the X and Y in our data are imperfect versions of the concepts we are interested in, for example:

- We want to know someone's overall life satisfaction but what we observe is how they ticked a box on a 1–5 scale on a particular day
- We want to measure wealth but only know about home ownership. This is certainly part of wealth but not all of it!
- Even for seemingly straightforward concepts like income, responses may lack accuracy or be limited (e.g., we know what a person earns this month, but not within a span of 10 years)
- Generally, survey data always come with some error: limited number of options, lack of attention, coding and transcription errors

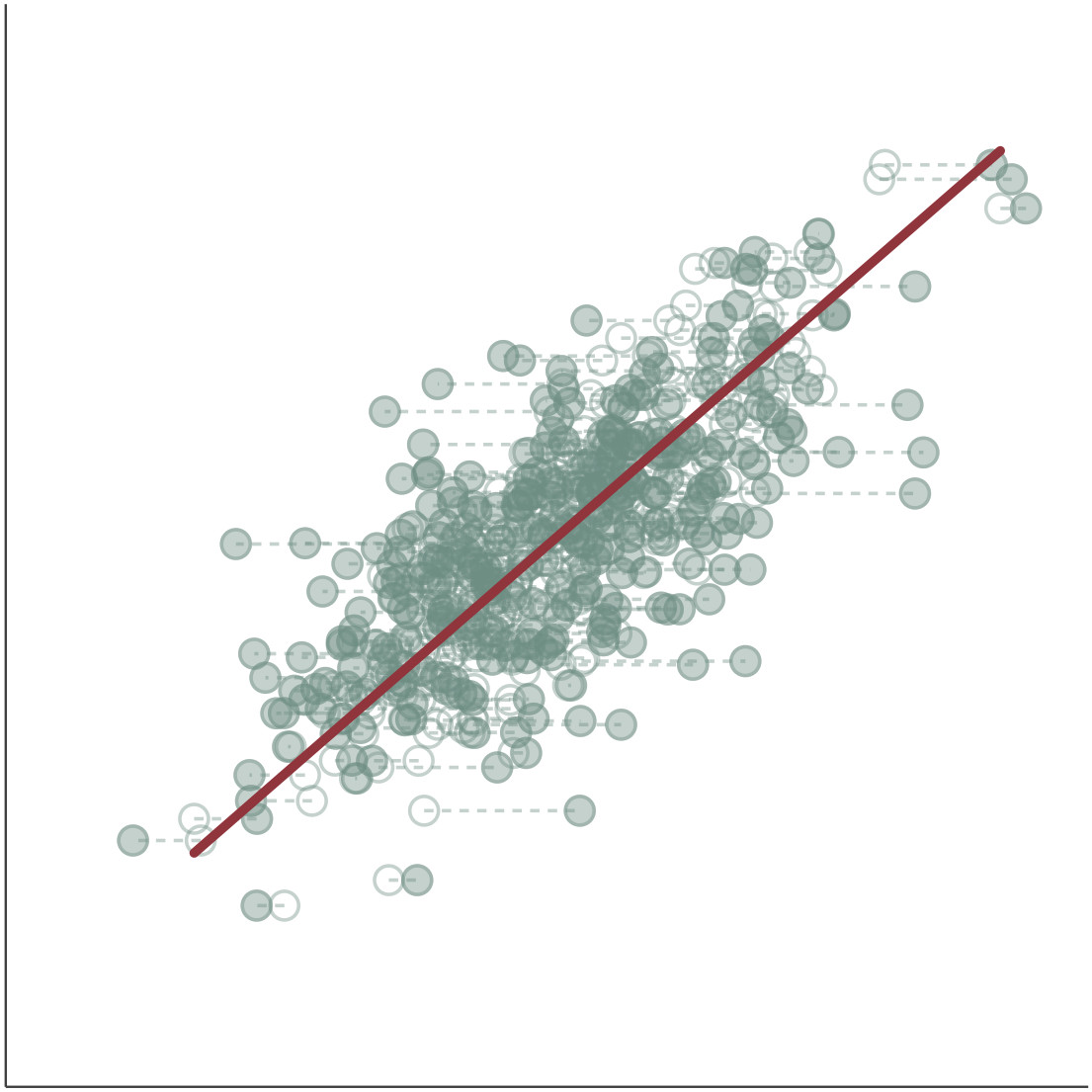
Consequences of random error in X

- True relationship



Consequences of random error in X

- True relationship
- Adding error in X



Consequences of random error in X

- True relationship
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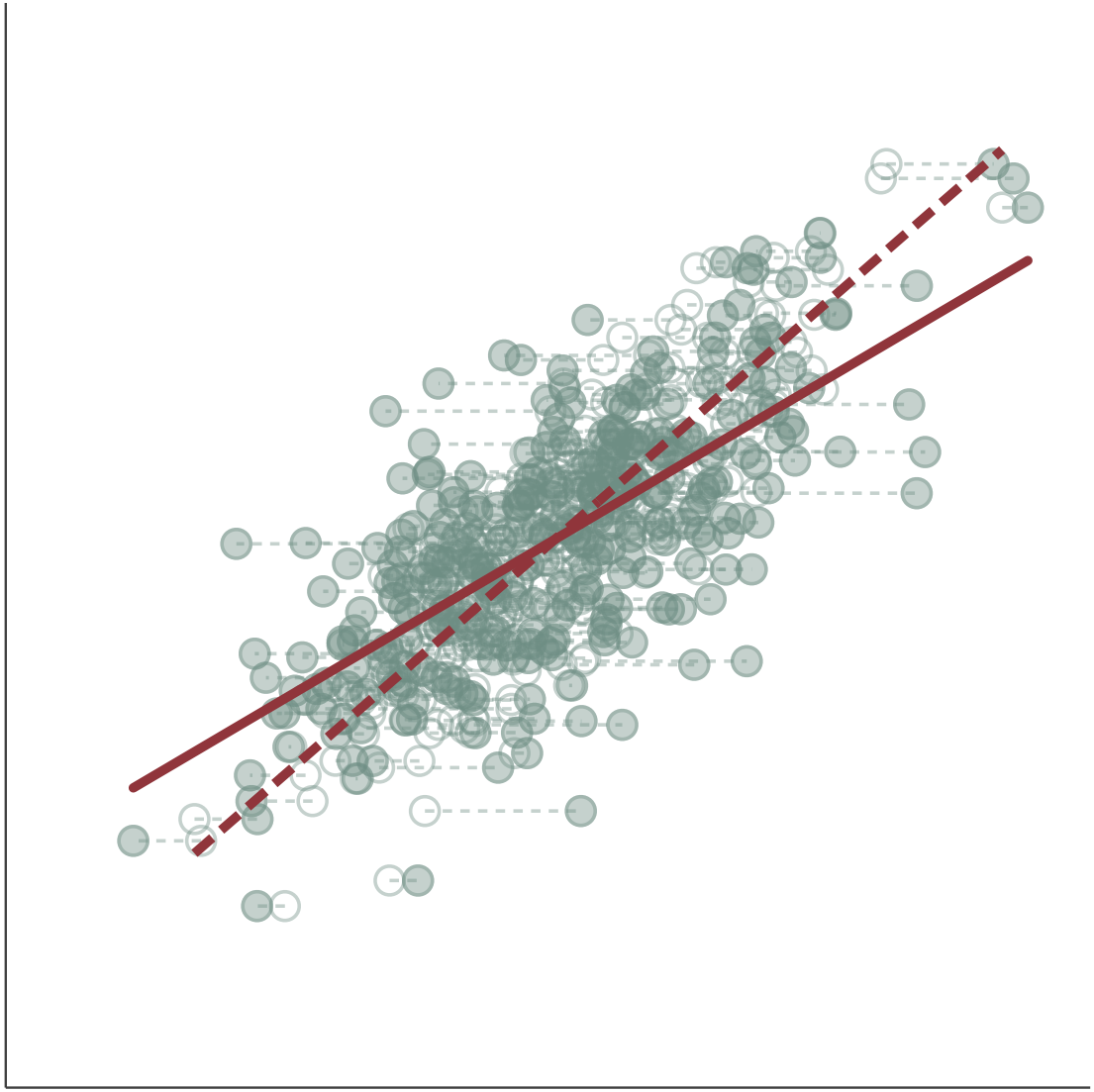
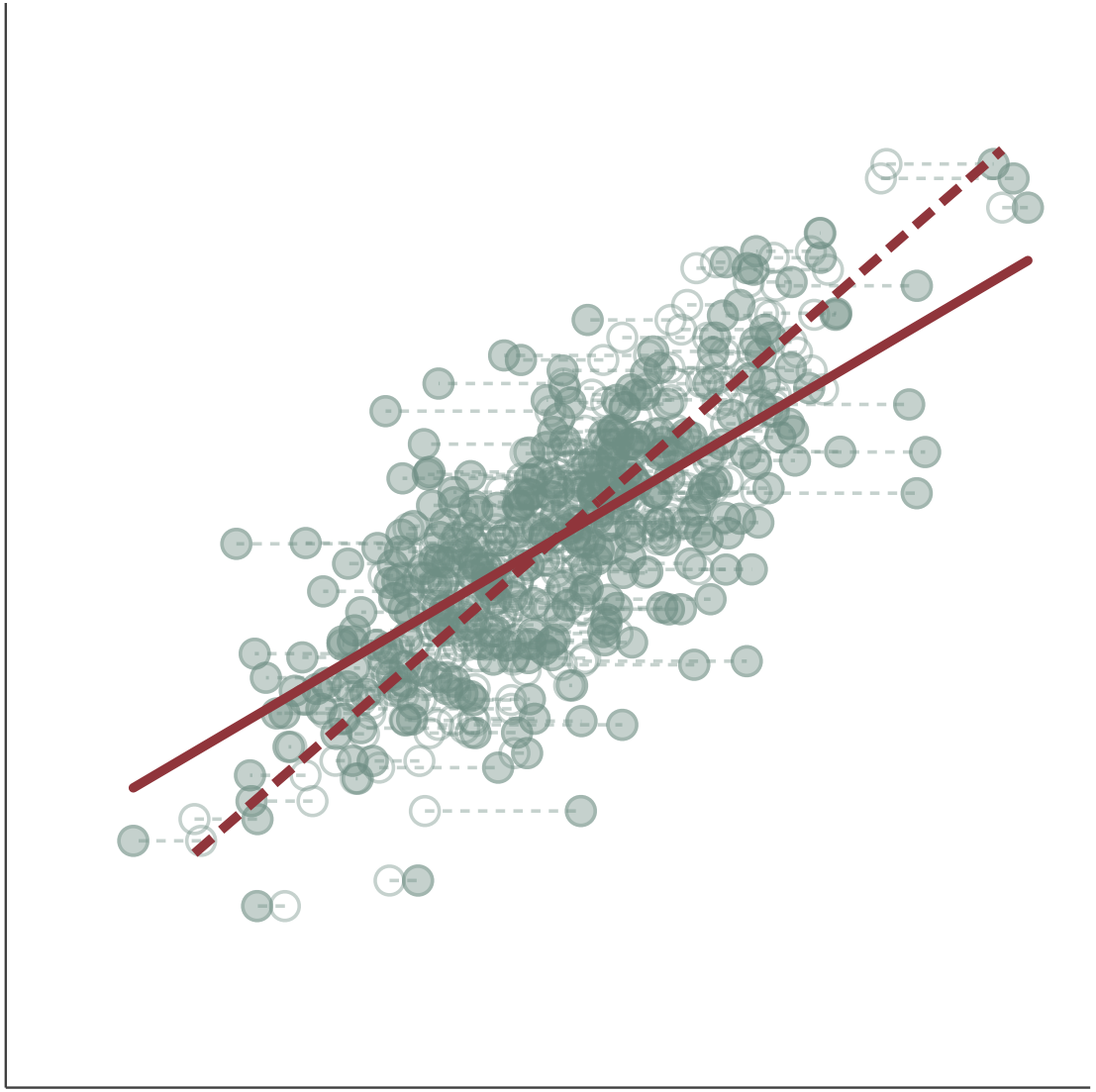
- Estimated relationship



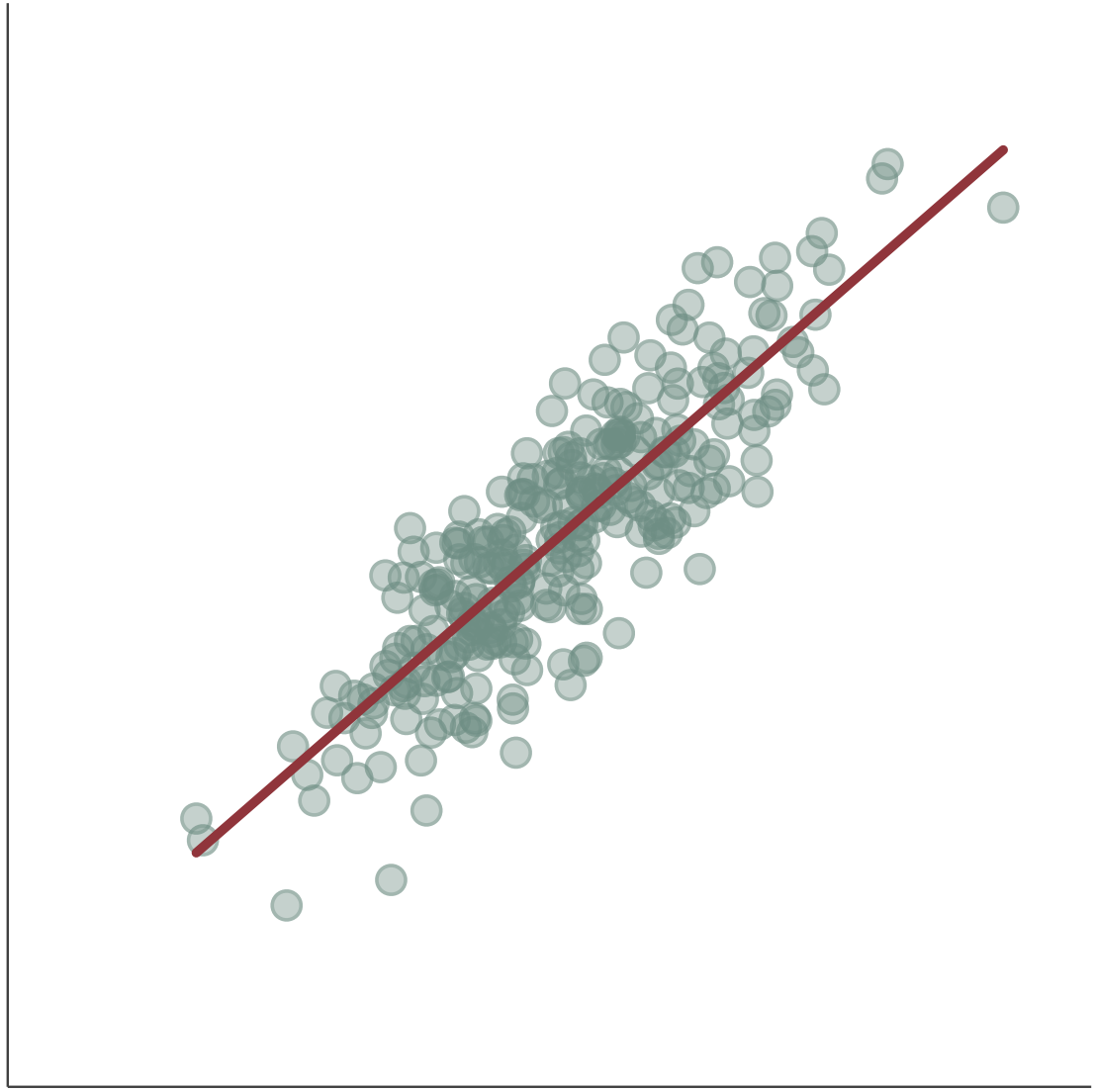
Consequences of random error in X

- True relationship
- Adding error in X
- Estimated relationship
- Estimate is weaker than the true effect



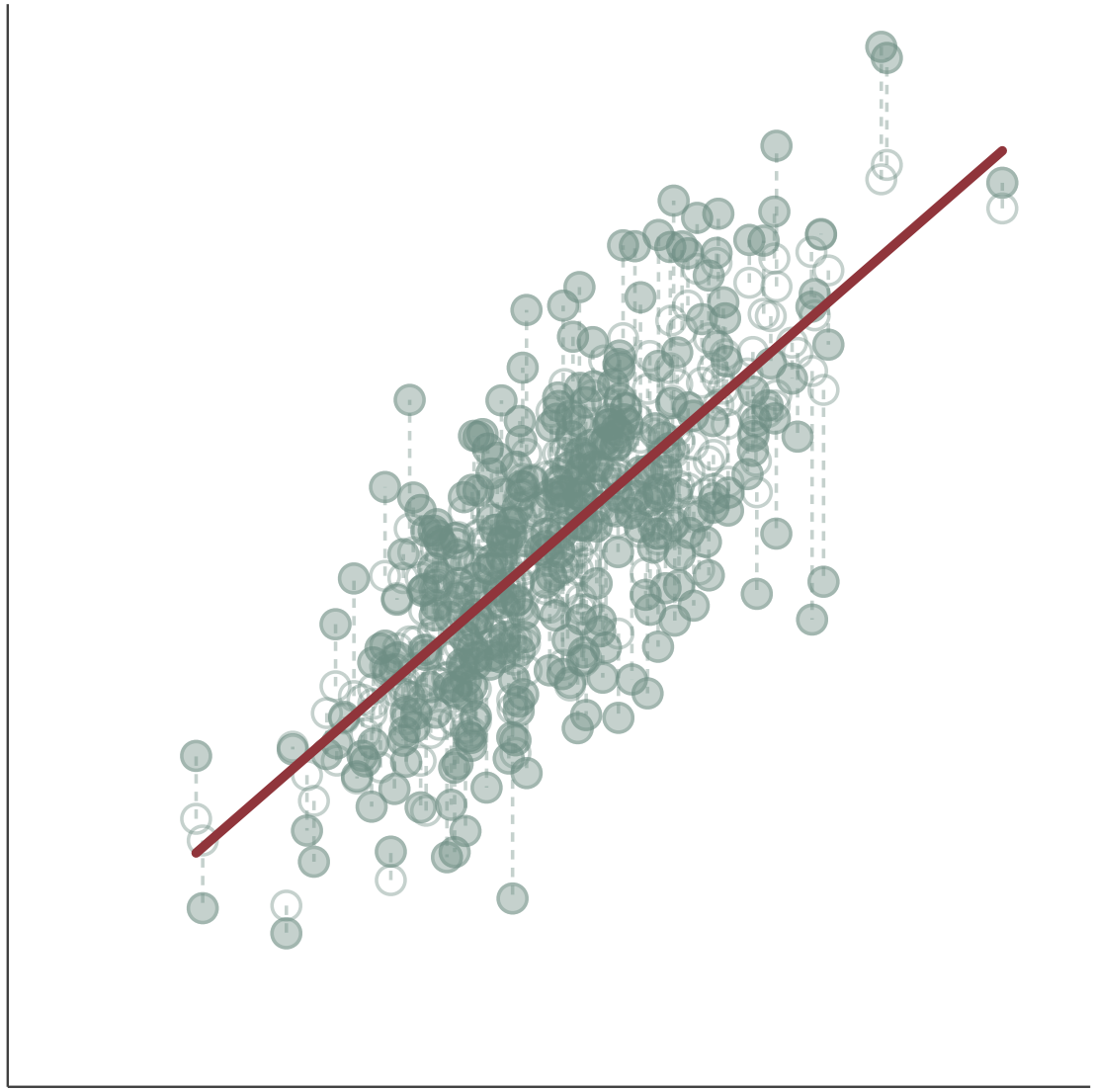
Consequences of random error in Y

- True relationship



Consequences of random error in Y

- True relationship
- Adding error in Y



Consequences of random error in Y

- True relationship
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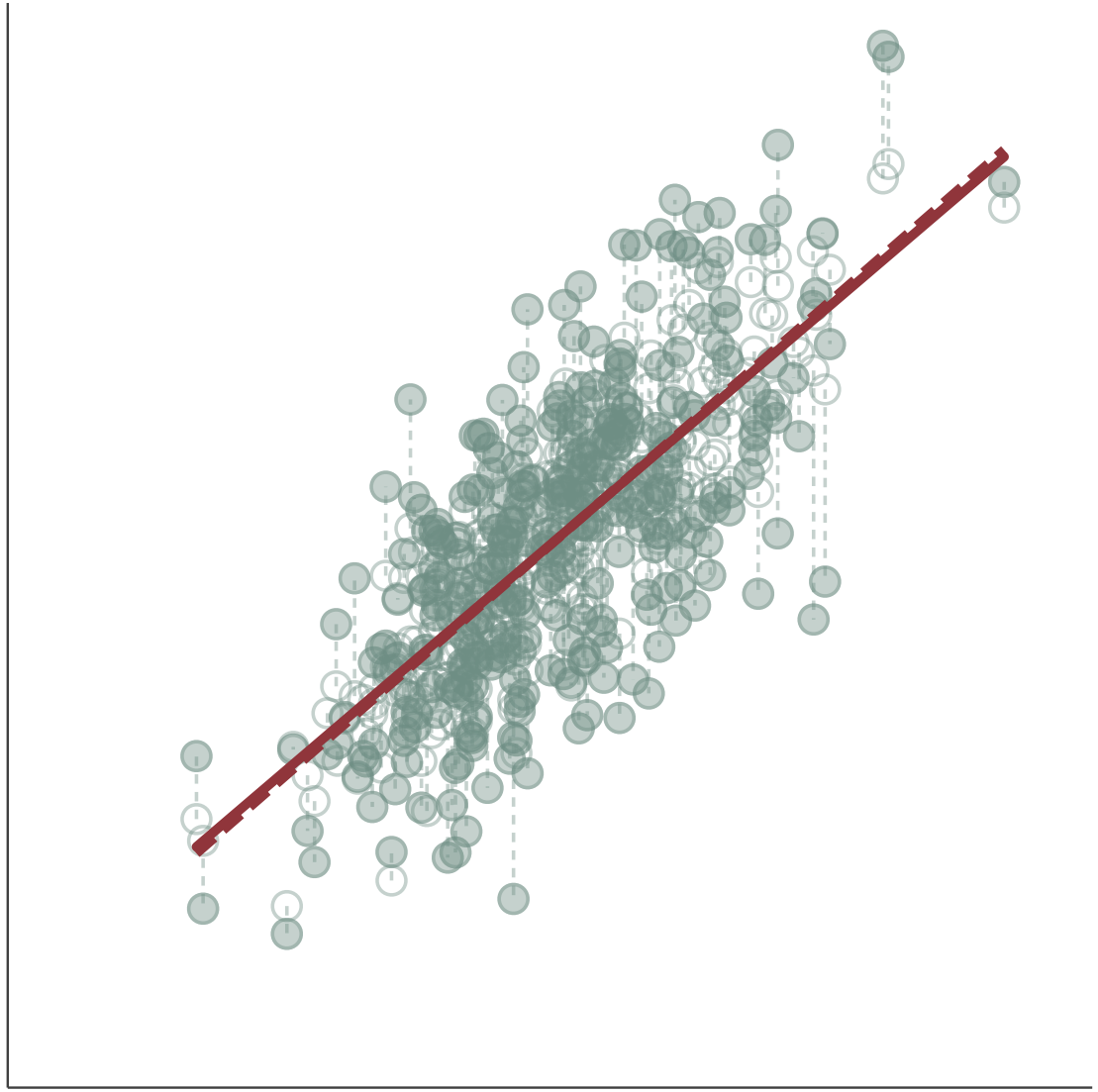
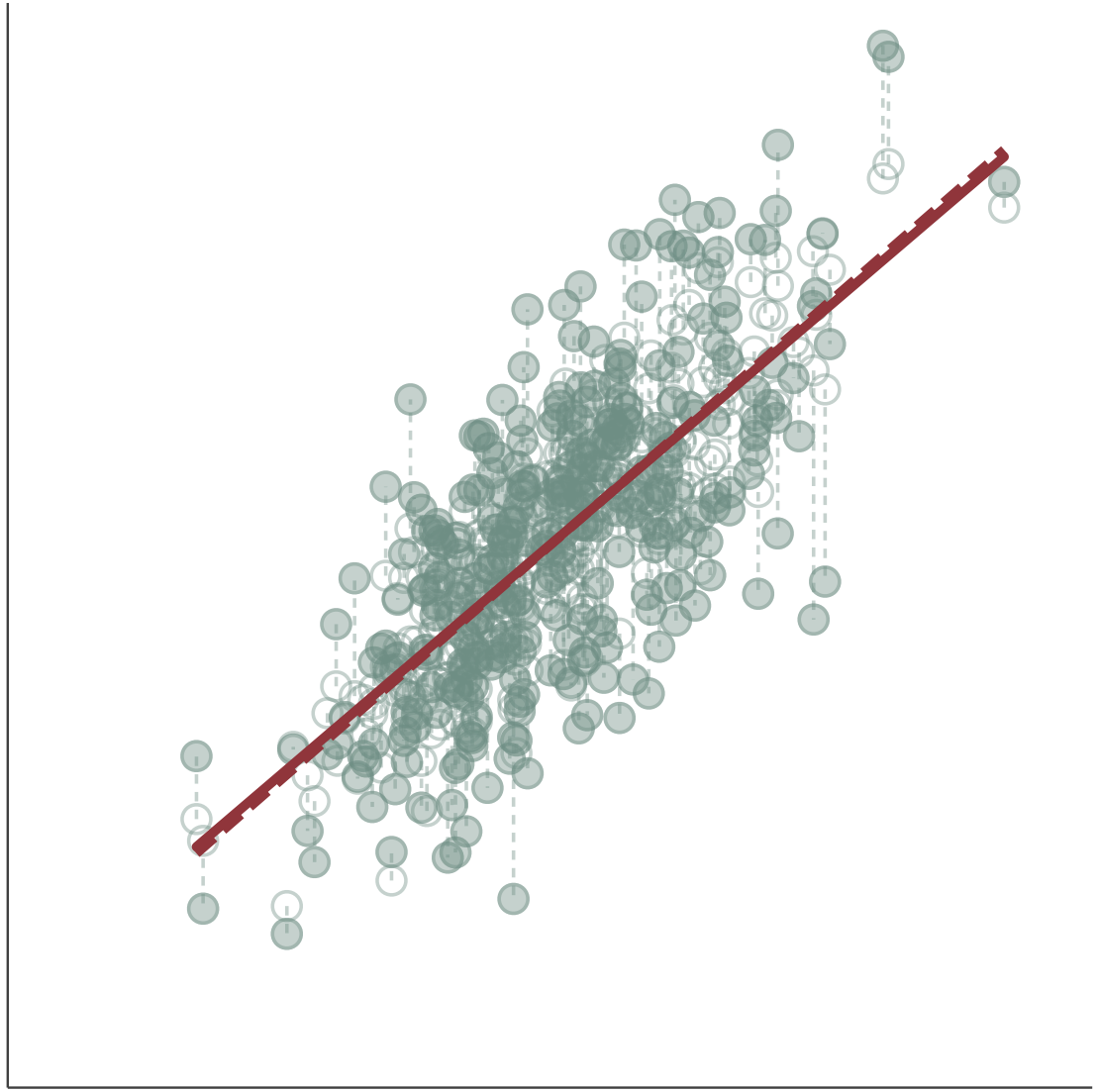


Consequences of random error in Y

- True relationship
- Adding error in Y
- Estimated relationship
- No difference here!



Consequences of measurement error

Random errors

- Random errors in X lead us to underestimate the effect (attenuation bias)
- Random errors in Y do not have any serious consequences
  - Note that this is the opposite of selection bias: for selection, it is selection on Y we should worry most about

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But what if errors are not random?

- Systematic errors arise when the error itself is correlated with X or Y
- Here we need to think carefully and reason about the possible direction of bias
  - Similar to self-selection or omitted variable bias

Systematic errors: example

- I want to know if number of books at home (X) influences children's reading scores (Y)
- I test children's reading and ask how many books they have at home
- Am I going to get an accurate answer?

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- Children who do not read will not be aware of books in the home
- In this case there is a systematic error where we underestimate books for low performing children
- Association between X and Y will look stronger than it actually is

Source: Engzell, P. (2021). What do books in the home proxy for? A cautionary tale. *Sociological Methods & Research*, 50(4), 1487-1514.

Solutions

- Collect better quality data, on a large number of observations
- Measure multiple indicators of concepts if possible (especially for systematic errors)
- Refine, check, validate measurement tools
- If aware of a systematic error discuss the implications

Simultaneity and Reverse Causality

- We want to know if X causes Y: $X \rightarrow Y$
- But we have seen that when we observe an association between X and Y, it doesn't necessarily mean that *X causes Y*

- **Reverse Causality**: $Y \rightarrow X$
- **Simultaneity**: $X \rightarrow Y$ and $Y \rightarrow X$

Examples

- 1) Positive association between hours spent playing **video games and behavioral problems**.
- But: does playing video games (X) cause children to become more violent (Y)? Or do more violent children play more video games?

$$\textit{Video games}\ (X) \longleftrightarrow\ \textit{Violence}(Y)$$

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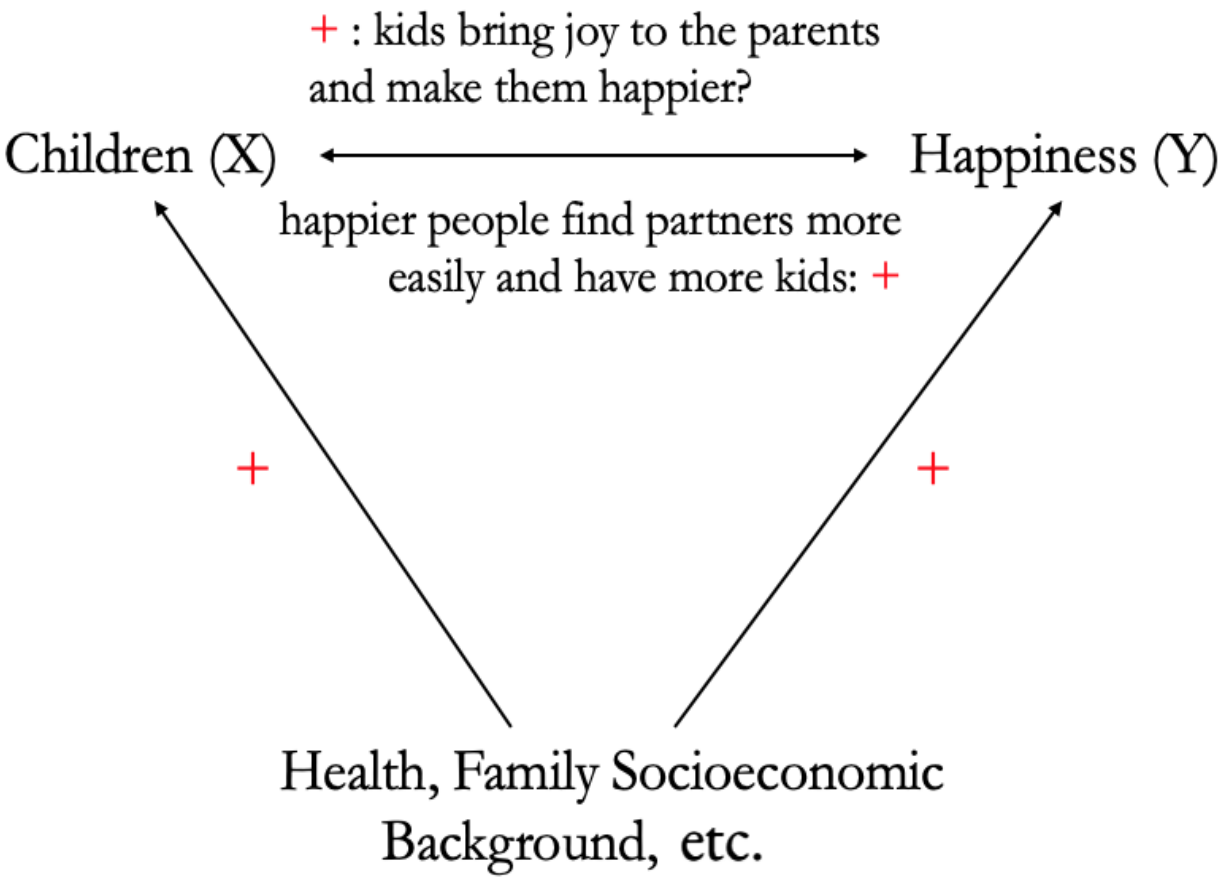
- 2) Positive association between **fertility and happiness**.
- But: Does having children (X) increase happiness (Y) Or do happier people (Y) tend to have more children (X)?

$$\textit{Fertility}\ (X) \longleftrightarrow \textit{Happiness}\ (Y)$$

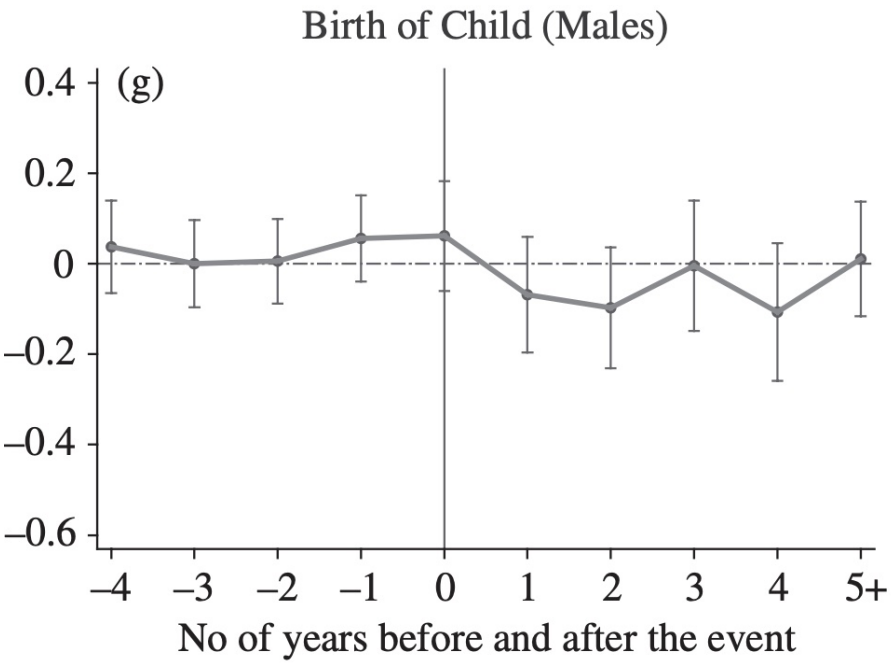
Children and Happiness

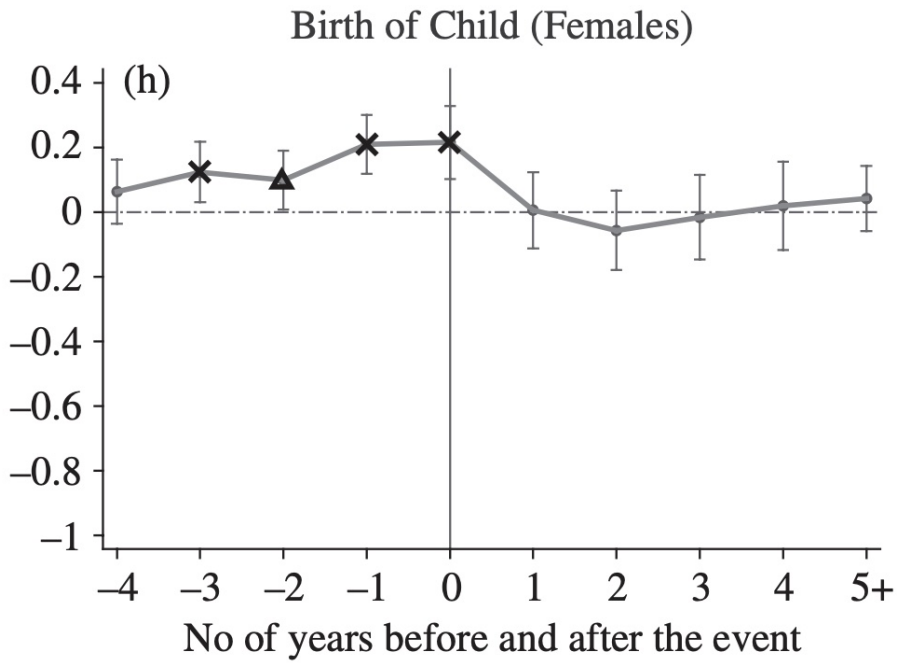


Solutions

- A powerful way is often to follow the same people over time
- This is sometimes called an event study or fixed-effects design
- In an experiment we make sure that control and treatment groups are balanced by randomizing treatment
- Here we make sure that control and treatment are balanced by comparing people to themselves before and after treatment
- We can see what came first: X or Y

Children and Happiness





Source: Clark, A. E., & Georgellis, Y. (2013). Back to baseline in Britain: adaptation in the British household panel survey. *Economica*, 80(319), 496-512.

Conclusion I

- Scientific process: Research Question, Theory, Hypothesis, Data, Evaluation
- Empirical evaluation of the hypothesis: Does X cause Y?
- How? Experiments are usually best (high internal validity), but not always possible and have external validity problems

- Other problems in studying causality (these are sometimes collectively referred to as endogeneity):
  - Selection
  - Omitted variable bias
  - Measurement error
  - Simultaneity/reverse causality

Conclusion II

- We always have to take into account these threats to internal validity when testing our hypotheses
- If we cannot address those threats empirically (e.g., no data on Z, no longitudinal data), we need to at least discuss these problems, the possibility of having biased results and the likely direction of bias

Seminar

Read Chetty et al. (2022)

1. What is the question, research design, and main finding?

2. The concept of socioeconomic status is central to both economic connectedness (X) and upward income mobility (Y).
   - How is socioeconomic status measured?
   - How is economic connectedness measured?
   - How is upward income mobility measured?

3. Potential bias
   - Do you see any risk for measurement error in socioeconomic status? Is this error random or systematic?
   - Do you see any risk for simultaneity/reverse causality between X and Y?