Causality (introduction)

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Credibility revolution (Econ Nobel 2021)

Ill. Niklas Elmehed © Nobel Prize Outreach.
David Card
Prize share: 1/2

Ill. Niklas Elmehed © Nobel Prize Outreach.
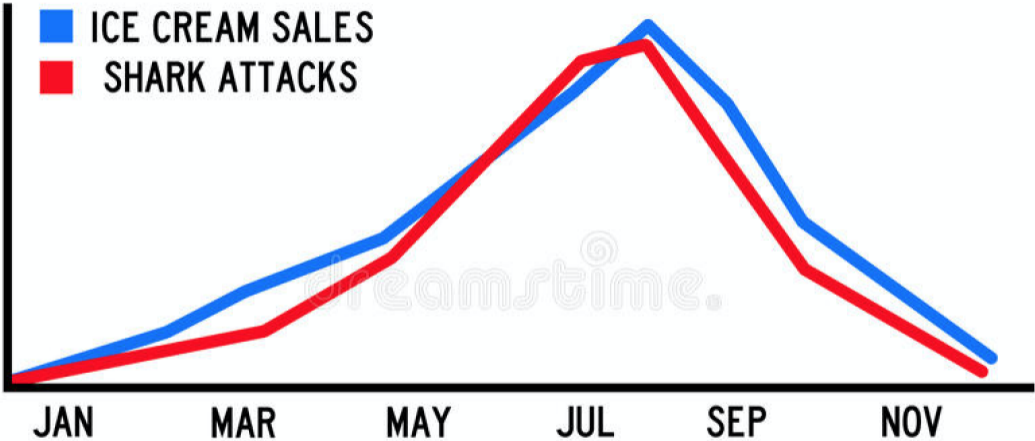Joshua D. Angrist
Prize share: 1/4

Ill. Niklas Elmehed © Nobel Prize Outreach.
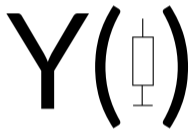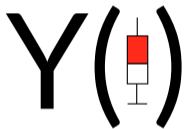Guido W. Imbens
Prize share: 1/4

https://www.nobelprize.org/prizes/economic-sciences/2021/summary/

Correlation ≠ Causation

Randomized experiment as a gold standard

Y(1)   Y(0)

Randomized experiment as a gold standard

$$Y(\text{💉}) \quad Y(\text{💉})$$

Randomized experiment as a gold standard

	$Y(1)$	$Y(0)$
Adam	4	
Boris	5	
Cyril		6
Diana		7
Ema	3	
Filip		3
...	...	...

Missing observations

	$Y(1)$	$Y(0)$
Adam	4	???
Boris	5	???
Cyril	???	6
Diana	???	7
Ema	3	???
Filip	???	3
...	...	...

	$Y(1)$	$Y(0)$	$Y(1) - Y(0)$
Adam	4	6	-2
Boris	5	7	-2
Cyril	8	6	2
Diana	3	7	-4
Ema	3	4	-1
Filip	1	3	-2
...	...	...	...

	$Y(1)$	$Y(0)$	$Y(1) - Y(0)$
Adam	4	6	-2
Boris	5	7	-2
Cyril	8	6	2
Diana	3	7	-4
Ema	3	4	-1
Filip	1	3	-2
...	...	...	...
mean	5.1	6.8	-1.6

	$Y(1)$	$Y(0)$
Adam	4	???
Boris	5	???
Cyril	???	6
Diana	???	7
Ema	3	???
Filip	???	3
...	...	...
mean	4.5	6.0

Estimated effect is

$$4.5 - 6.0 = -1.5$$

We need the intervention to be **random**.

$$D \in \{\,\blacksquare,\ \square\,\}$$

$$Y(1), Y(0) \perp\!\!\!\perp D$$

And this is the problem

To answer many many interesting question we simply cannot conduct a proper experiment

- Do veterans have lower wages because of the war?
- Does education increase wages?
- What is the slope of a demand curve?
- How does minimum wage affect unemployment?
- Does classroom size affect students' performance?
- Does alcohol consumption increase the probability of a car crash?
- Will a job training improve candidate's chances of getting a job?
- Does more information improve market efficiency?
- ...

Solution nr.1 (?)

Make use of information (X) for prediction of D.

$$Y(1), Y(0) \perp\!\!\!\perp D | X$$

We compare similar units.

Solution nr.2 (?)

We need a

SOURCE OF RANDOMNESS

"Quasi-experiment"

$$D \rightarrow Y$$

$$Z \rightarrow D \rightarrow Y$$

$$Z \nrightarrow Y$$

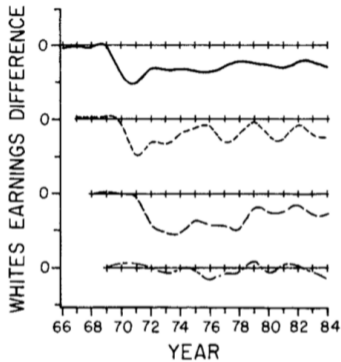$$\hat{\beta} = \frac{effect(Z \rightarrow Y)}{effect(Z \rightarrow D)}$$

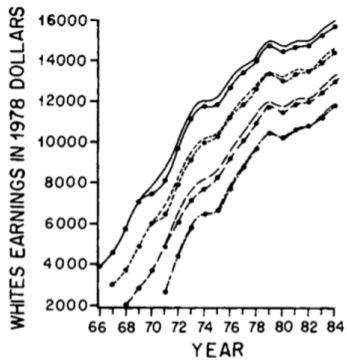$$\hat{\beta} = \frac{Cov(Y, Z)}{Cov(D, Z)}$$

$$\hat{\beta} = \frac{E[Y|Z=1] - E[Y|Z=0]}{E[D|Z=1] - E[D|Z=0]}$$

Vietnam draft lottery (Angrist, 1990)
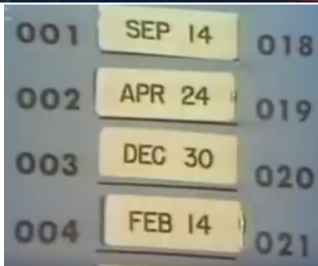
Vietnam draft lottery $Z \to Y$
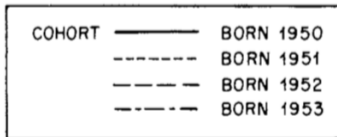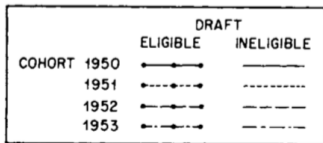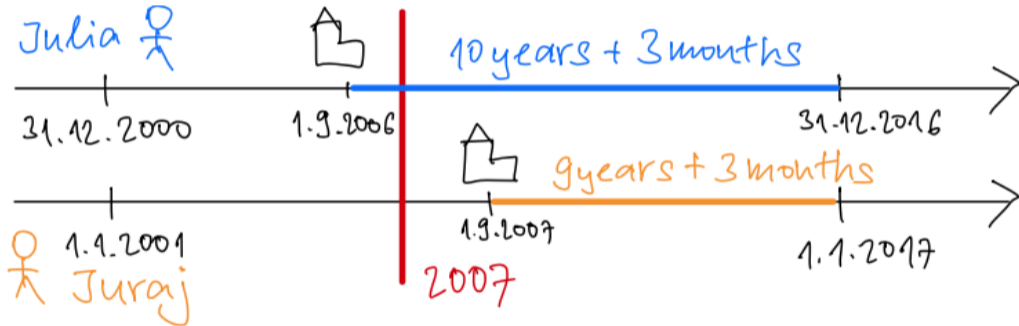
Is education worth it? (Angrist and Krueger, 1991)

Is education worth it?

$$\log(\texttt{wage}) = \beta_0 + \beta_1 \texttt{education} + \beta_2 \texttt{age} + \varepsilon$$

$$\log(\texttt{wage}) = \beta_0^* + \beta_1^* \texttt{education} + \beta_2^* \texttt{age} + \beta_3^* \texttt{ability} + \varepsilon$$
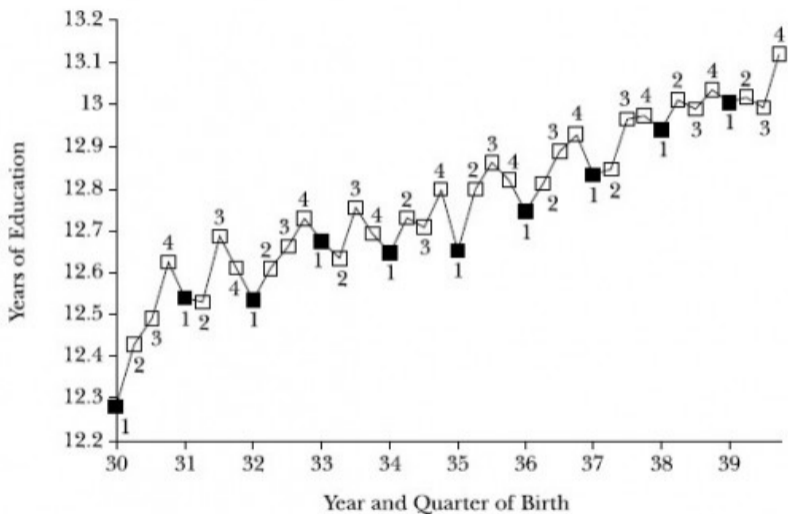
$$\texttt{ability} = \gamma_0 + \gamma_1 \texttt{education} + \varepsilon'$$

$$\log(\texttt{wages}) = (\beta_0^* + \beta_3^* \gamma_0) + \underbrace{(\beta_1^* + \beta_3^* \gamma_1)}_{\beta_1} \texttt{education} + \beta_2^* \texttt{age} + (\beta_3^* \varepsilon' + \varepsilon)$$
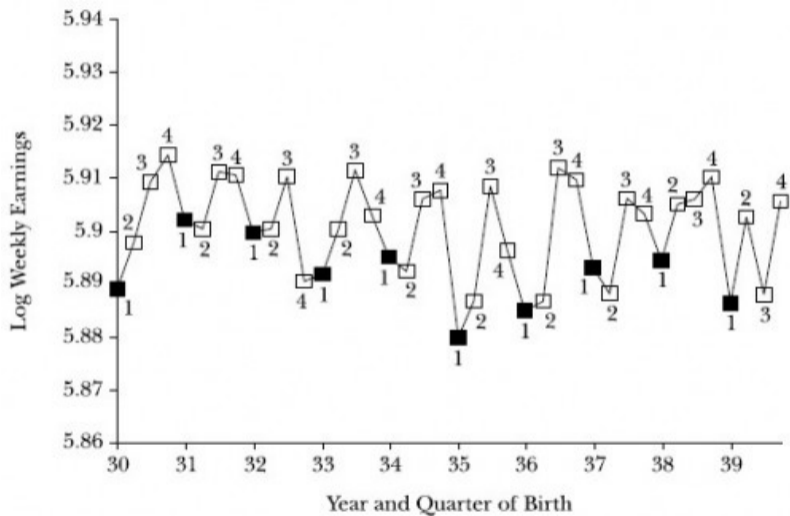
Is education worth it?

Julia

31.12.2000   1.9.2006   10 years + 3 months   31.12.2016

Juraj   1.1.2001

1.9.2007   9 years + 3 months   1.1.2017

2007

Is education worth it? $Z \rightarrow D$

Is education worth it? $Z \rightarrow Y$

Is education worth it?

Results

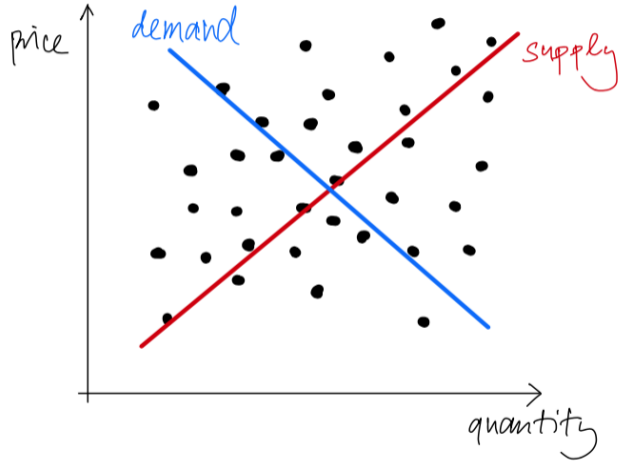- one year of extra schooling predicts and wage increase in about 7%

Critique

- Is the quarter of birth truly random?
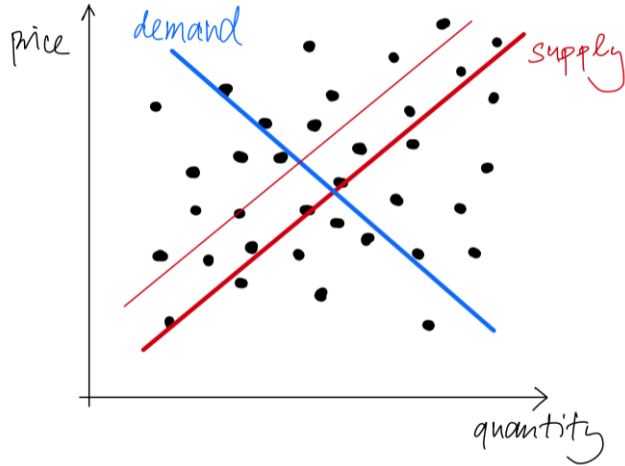- The association between the quarter of birth and years of schooling is only weak.

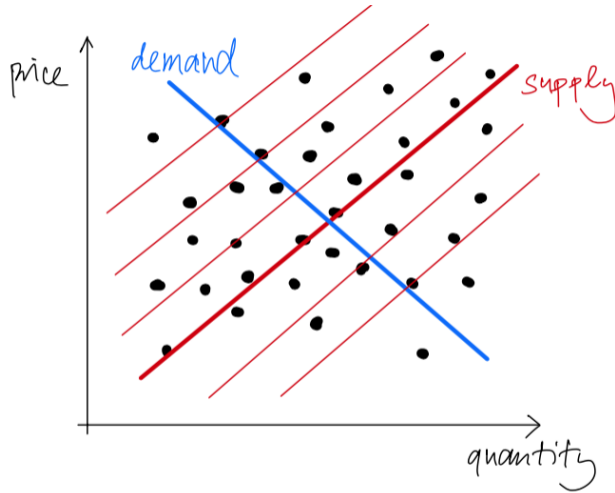# Demand for fish (Angrist, Graddy and Imbens 2000)
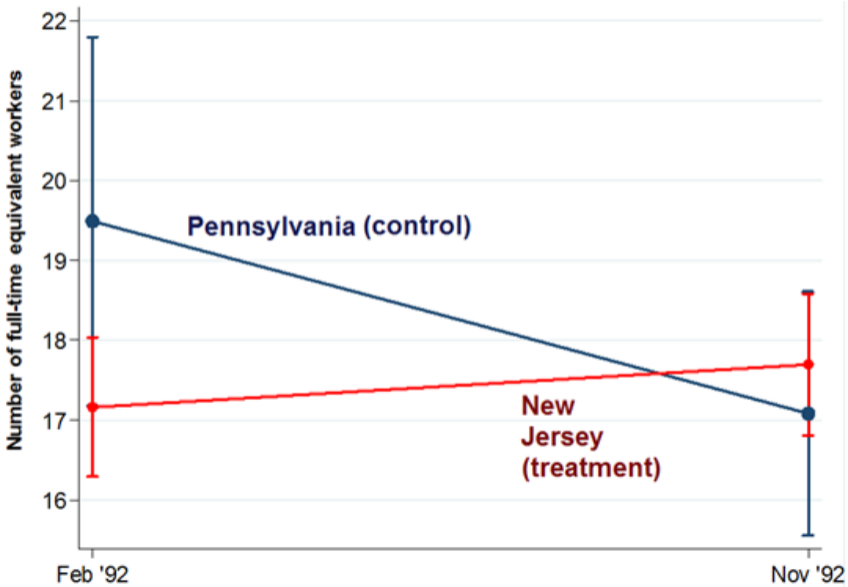
Demand curve

Demand curve

Demand curve

The effect of minimum wage on unemployment (Card and Krueger, 1994)
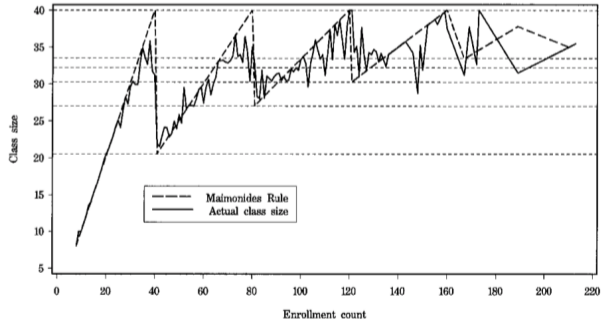
The effect of minimum wage on unemployment

Classroom size: does it matter? (Angrist and Lavy, 1999)

www.fishownerguide.com

Does classroom size predict students' performance?

40 students → 1 class

41 students → 2 classes

(Angrist and Lavy, 1999)

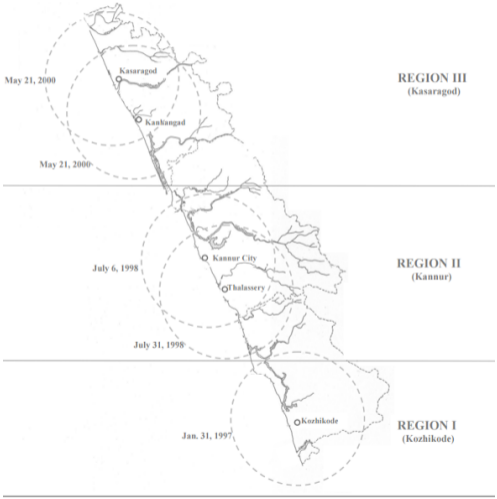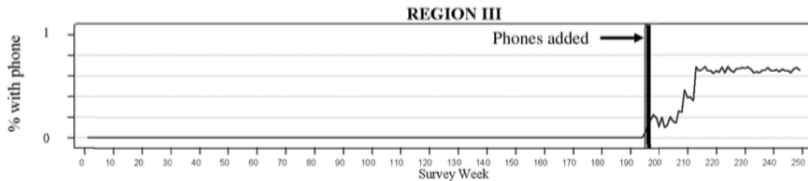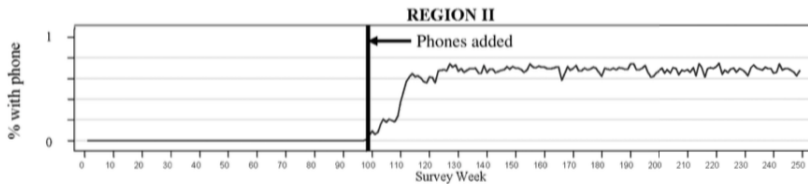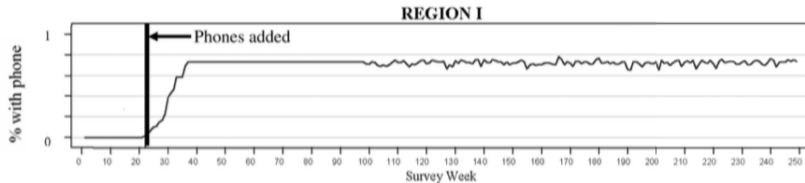# Access to information and market efficiency (Jensen, 2007)

FIGURE II
SPREAD OF MOBILE PHONE COVERAGE IN KASARAGOD, KANNUR AND KOZHIKODE DISTRICTS

Access to information and market efficiency
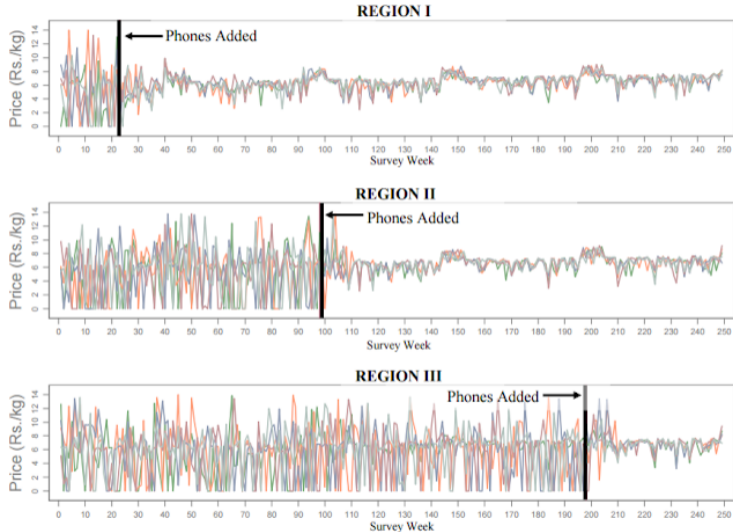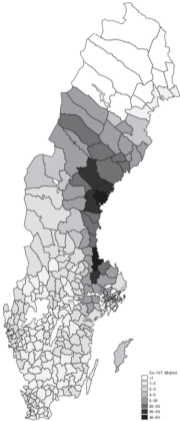
Access to information and market efficiency

FIGURE IV
PRICES AND MOBILE PHONE SERVICE IN KERALA

Radioactive fallout
(Almond et al. 2007) (Black et al. 2019)

www.fishownerguide.com

Radioactive fallout
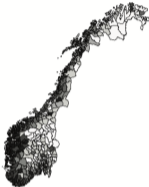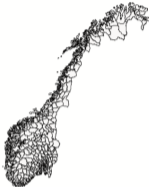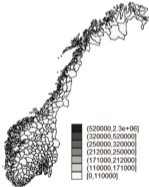
Problems

Can we generalize from the sample to the whole population?

The effect can be heterogenous.

Are the "natural" experiments truly random?

More difficult problems - we need a model

Model as a map

The model should be useful and not true.

Broken experiment

There are many other problems even with proper experiments

- People do not respond.
- Measurement error.
- Sample is too specific.
- Conditions has changed.

Qualitative support for causality

- Effect is **strong.**
- Effect is **consistent.**
- Effect is **specific.**
- Effect **is time consistent.**
- Effect is **monotonous**.
- Effect is **plausible**.
- Effect is **confirmed by an experiment**.

Summary

We need a source of randomness

- lottery
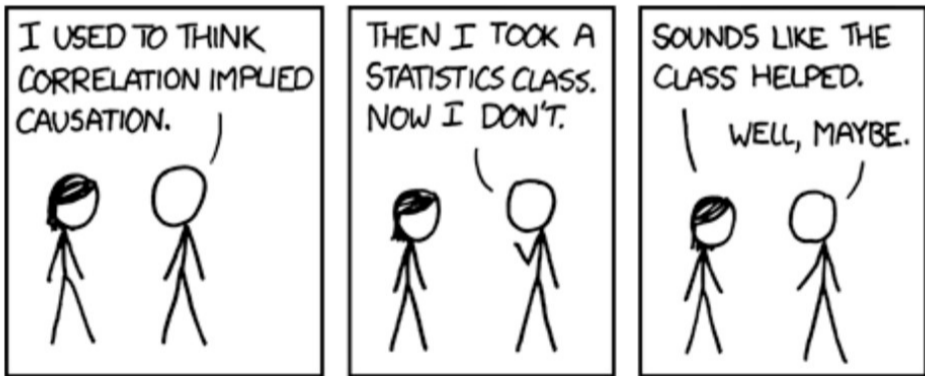- nature
- legislative change
- ...

Results

- are based on models. These could be sensible or less sensible.
- we should be critical
- relevant for a specific subpopulation.

Despite all these problems

- some questions are so important that even an imperfect answer is better than nothing.

This was the soft intro, now we are ready to start.

https://xkcd.com/552/

References

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