Causality (introduction)

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11.11.2021

Credibility revolution (Econ Nobel 2021)

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

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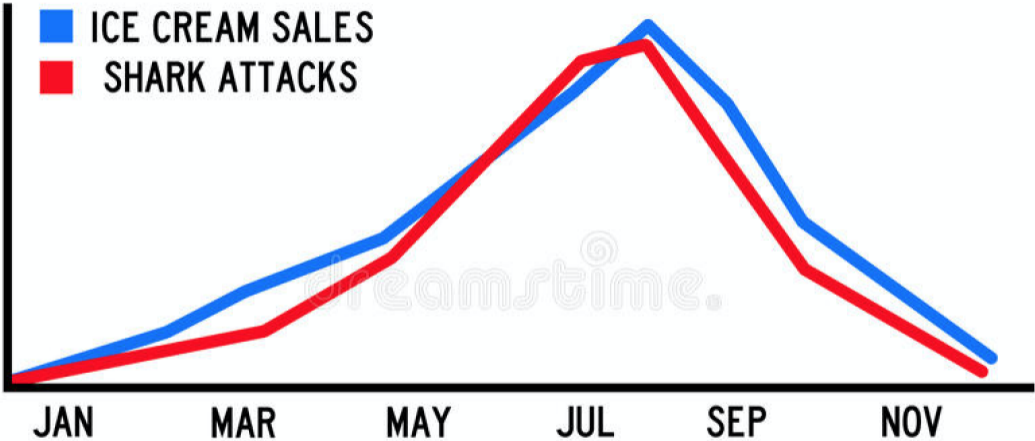Joshua D. Angrist
Prize share: 1/4

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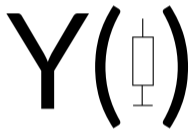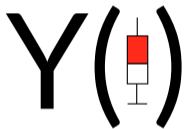Guido W. Imbens
Prize share: 1/4

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

Correlation ≠ Causation

ICE CREAM SALES
SHARK ATTACKS

JAN   MAR   MAY   JUL   SEP   NOV

Randomized experiment as a gold standard

Y(1)   Y(0)

Randomized experiment as a gold standard

$$Y(\text{💉}) \qquad Y(\text{💉})$$

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**.

$$D \in \{\text{❗},\text{◻}\}$$

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

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.

We need a

SOURCE OF RANDOMNESS

"Quasi-experiment"

$$D \rightarrow Y$$

$$Z \rightarrow D \rightarrow Y$$

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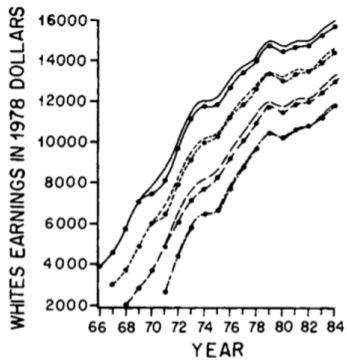
$$\hat{\beta} = \frac{effect(Z \rightarrow Y)}{effect(Z \rightarrow D)}$$

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

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

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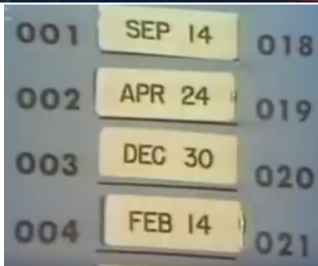
Vietnam draft lottery $Z \rightarrow Y$
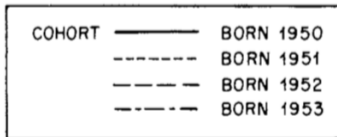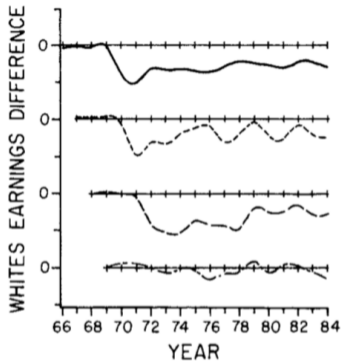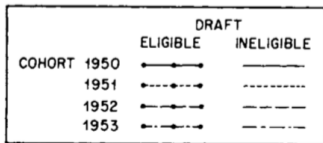
Is education worth it? (Angrist and Krueger, 1991)

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

2007

1.4.2001   1.9.2007   9 years + 3 months   1.1.2017
Juraj
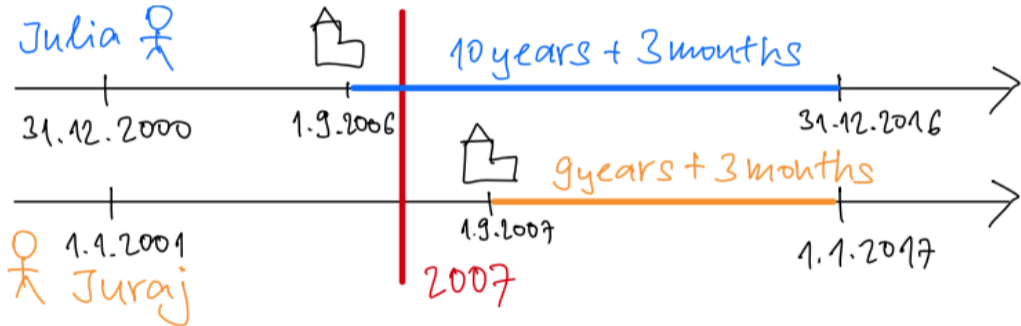
Is education worth it? $Z \rightarrow D$
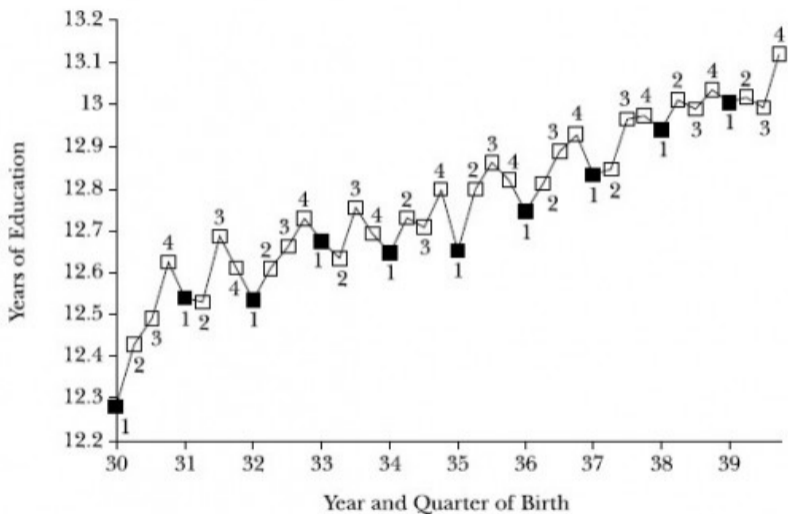
Is education worth it? $Z \rightarrow Y$
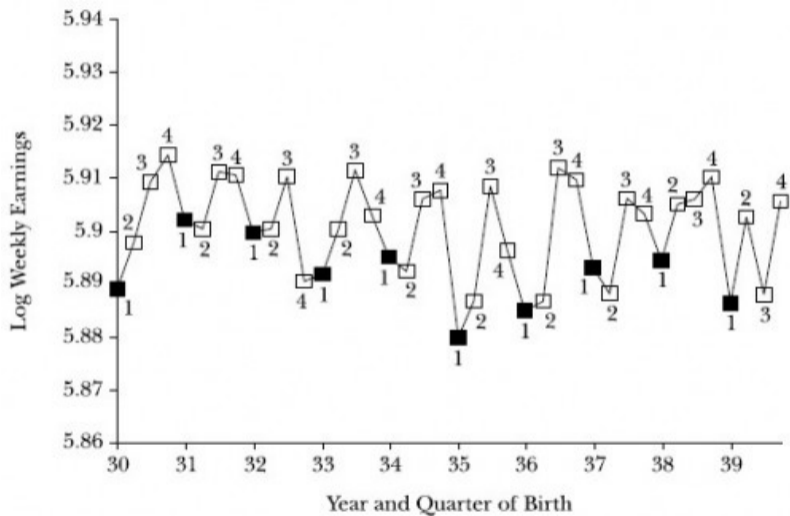
Is education worth it?

Results

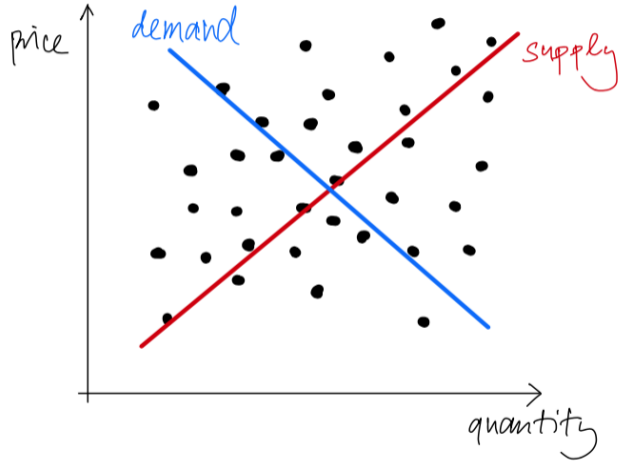- one year of extra schooling predicts and wage increase in about 7%

Critique

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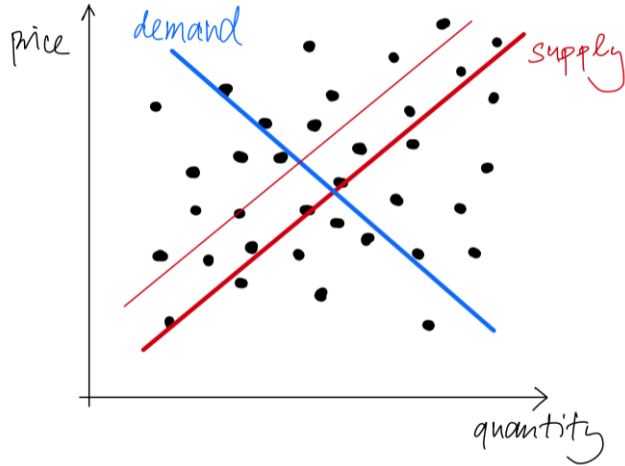- The association between the quarter of birth and years of schooling is only weak.

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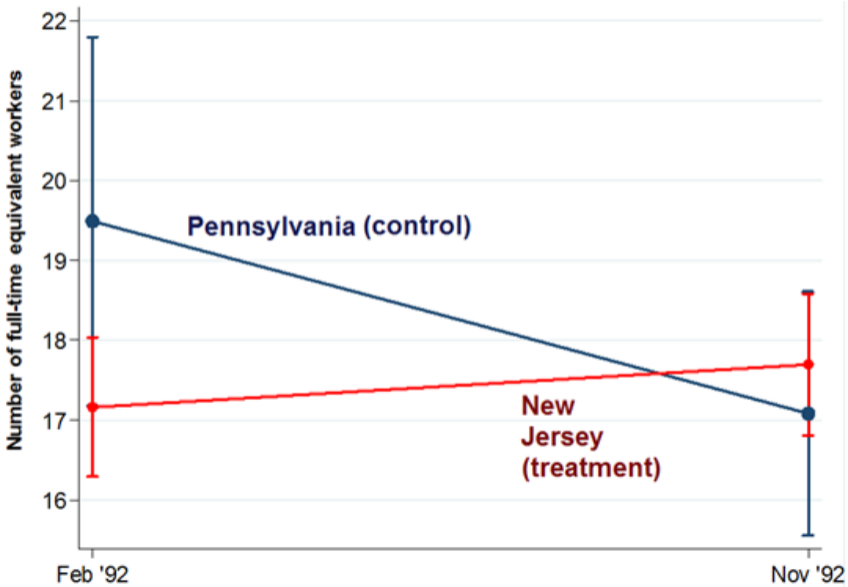
Demand curve

Demand curve

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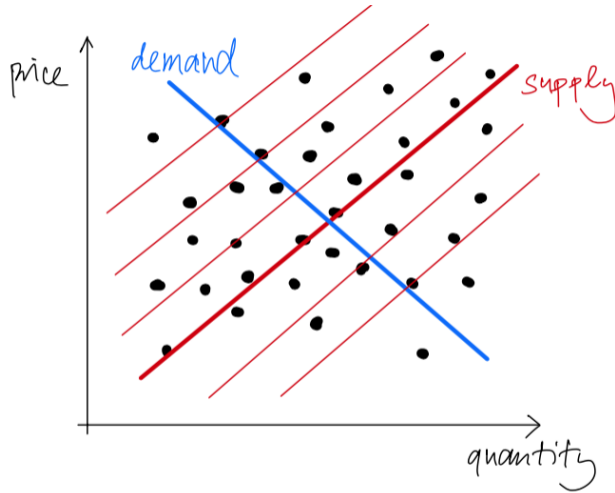
The effect of minimum wage on unemployment (Card and Krueger, 1994)
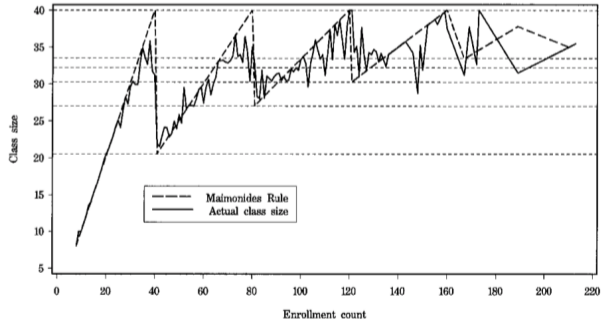
The effect of minimum wage on unemployment

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

Does classroom size predict students' performance?

40 students → 1 class

41 students → 2 classes

(Angrist and Lavy, 1999)
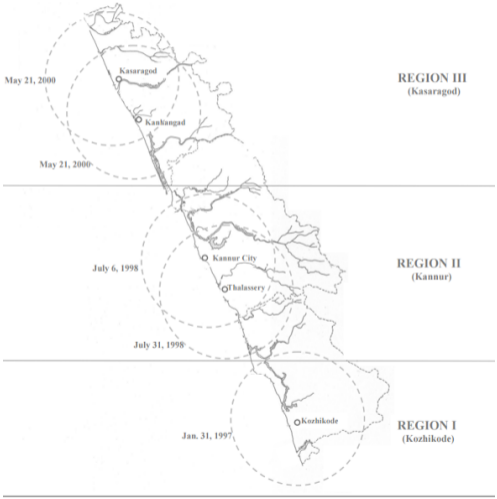
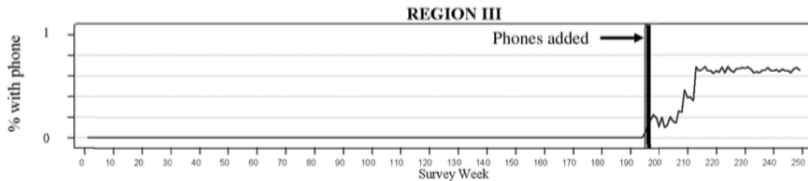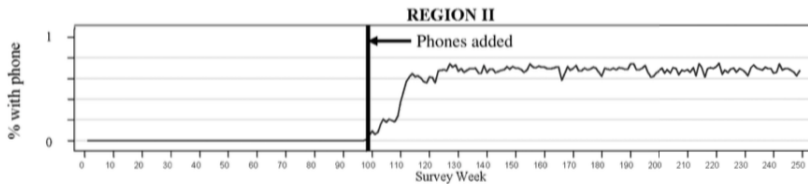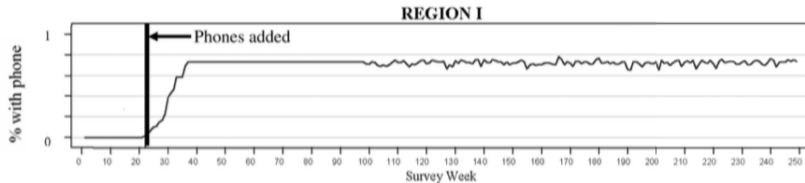# Access to information and market efficiency (Jensen, 2007)

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

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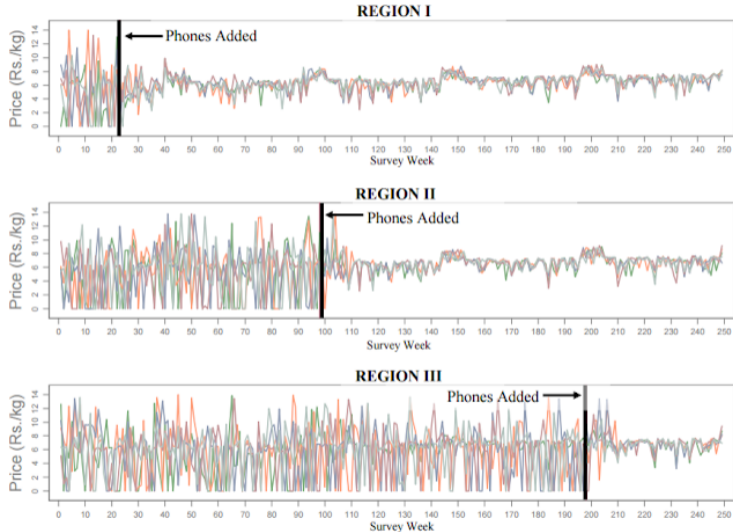
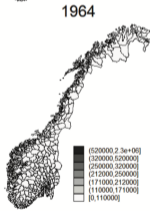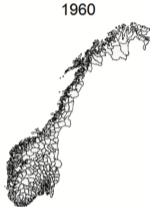# Access to information and market efficiency

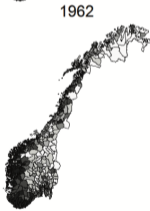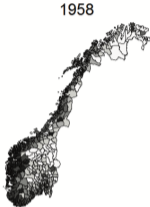**FIGURE IV**
PRICES AND MOBILE PHONE SERVICE IN KERALA

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

Radioactive fallout
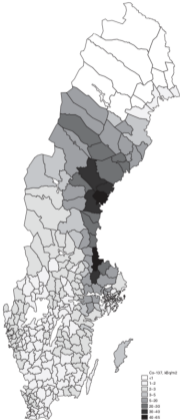
Problems

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
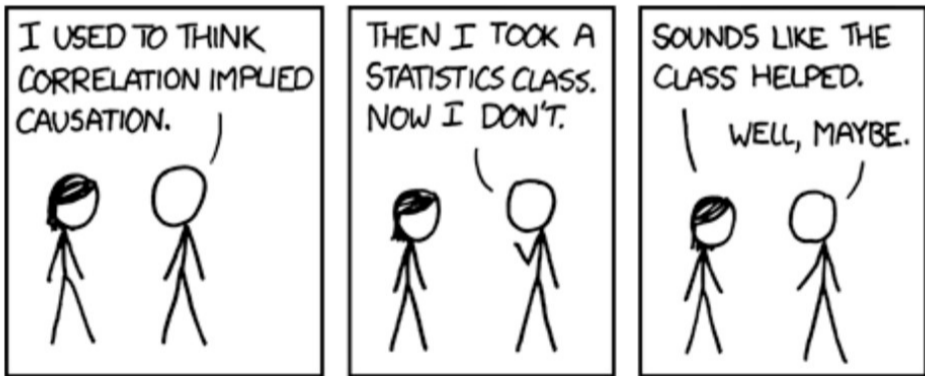- nature
- legislative change
- ...

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

- Angrist, Joshua D. "Lifetime earnings and the Vietnam era draft lottery: evidence from social security administrative records." The American Economic Review (1990): 313-336.
- Angrist, Joshua D., and Alan B. Keueger. "Does compulsory school attendance affect schooling and earnings?." The Quarterly Journal of Economics 106.4 (1991): 979-1014.
- Angrist, Joshua D., Kathryn Graddy, and Guido W. Imbens. "The interpretation of instrumental variables estimators in simultaneous equations models with an application to the demand for fish." The Review of Economic Studies 67.3 (2000): 499-527.
- Card, David, and Alan B. Krueger. "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania." American Economic Review 84.4 (1994): 772-93.
- Angrist, Joshua D., and Victor Lavy. "Using Maimonides' rule to estimate the effect of class size on scholastic achievement." The Quarterly journal of economics 114.2 (1999): 533-575.
- Jensen, Robert. "The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector." The quarterly journal of economics 122.3 (2007): 879-924.
- Almond, Douglas, Lena Edlund, and Mårten Palme. "Chernobyl's subclinical legacy: prenatal exposure to radioactive fallout and school outcomes in Sweden." The Quarterly journal of economics 124.4 (2009): 1729-1772.
- Black, Sandra E., et al. "This is only a test? Long-run and intergenerational impacts of prenatal exposure to radioactive fallout." Review of Economics and Statistics 101.3 (2019): 531-546.