Introduction to Instrumental Variables

Econ 140, Section 7

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Roadmap

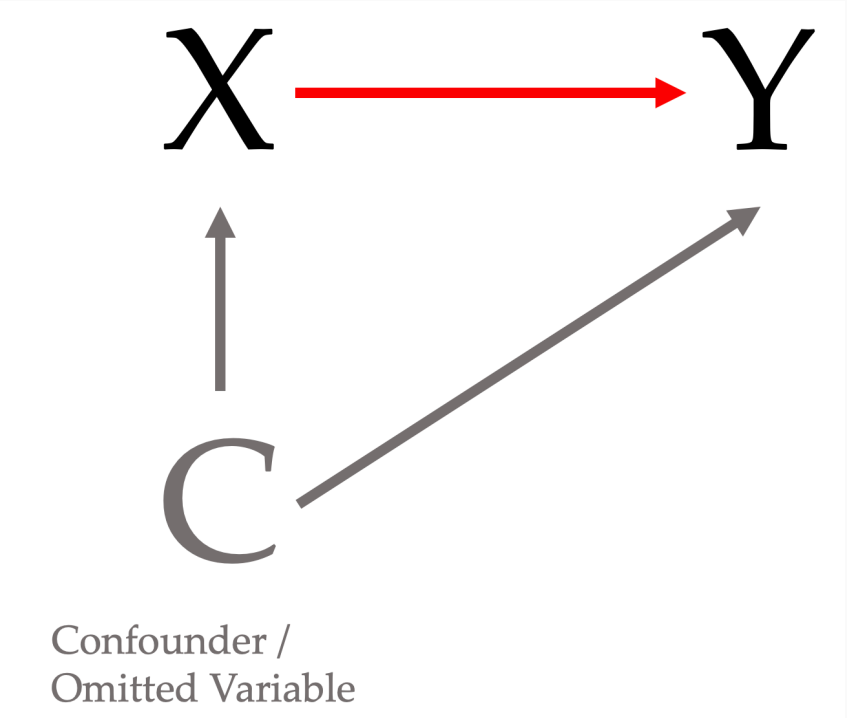
1. Introduction to Instrumental Variables
2. IV Conditions
3. IV Summary
4. Group work
5. Section Assignment

Any questions?

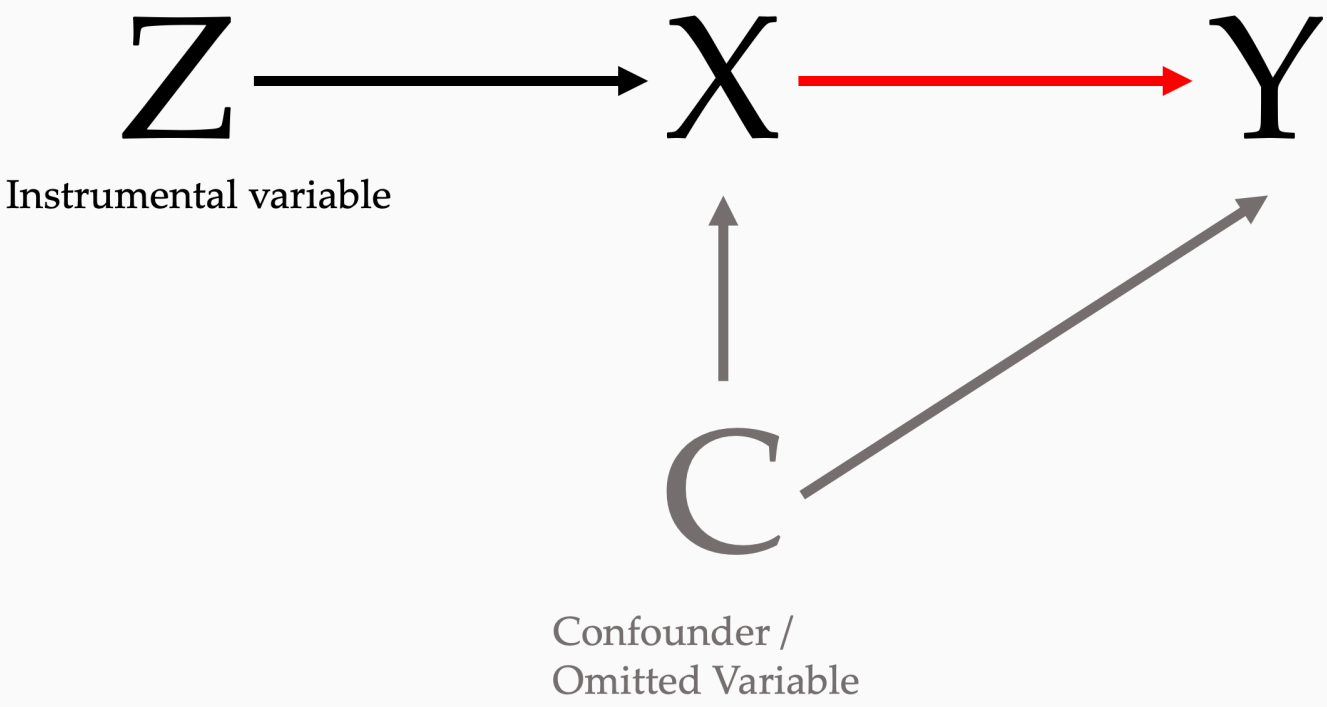
… Remember – Every question is useful!

Introduction to Instrumental Variables

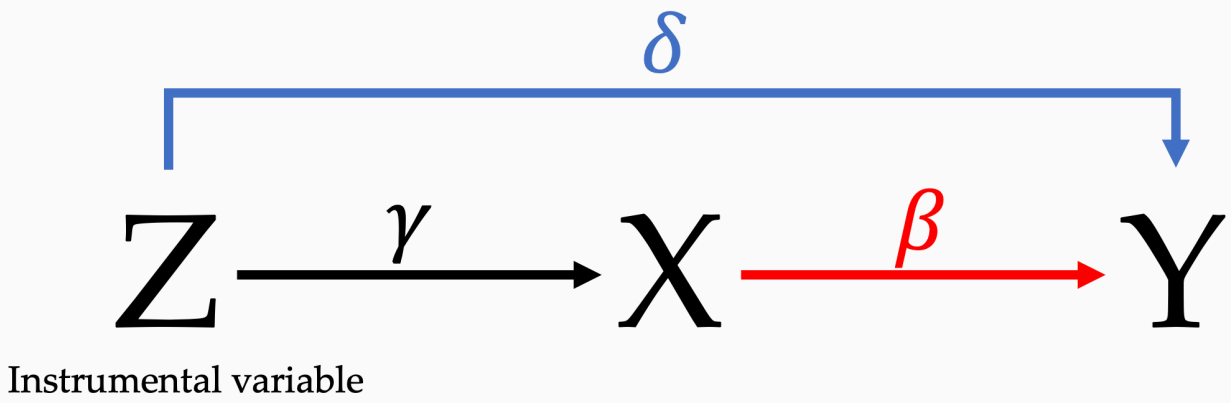
Recap: Omitted Variable Bias



Instrumental variables: The setup



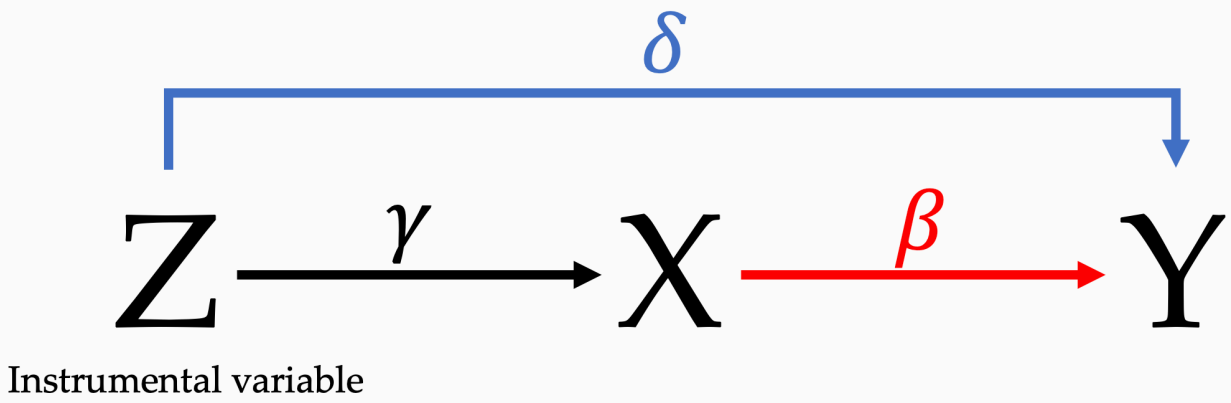
Recap: IV ”rescales” the effect



A simple example:

- We want to know the effect of chocolate (X) on happiness (Y), using a randomized voucher as instrument (Z).
- We find: people with voucher were 3 points more happy ($\delta = 3$), and ate 0.5 more chocolates ($\gamma = 0.5$).
- Then, the effect of eating one more chocolate is:

Recap: IV "rescales" the effect



A simple example:

- We want to know the effect of chocolate (X) on happiness (Y), using a randomized voucher as instrument (Z).
- We find: people with voucher were 3 points more happy ($\delta = 3$), and ate 0.5 more chocolates ($\gamma = 0.5$).
- Then, the effect of eating one more chocolate is: $\beta = \delta/\gamma = 3/0.5 = 6$.

Calculating the IV coefficient

What is the effect of **eating chocolate** (D) on happiness (Y).

- Why not estimate: $Y_i = \alpha + \beta D_i + \varepsilon_i$?

Randomly give voucher to buy chocolate at 90% discount (Z).

- Why not estimate: $Y_i = \alpha + \beta Z_i + \varepsilon_i$?

Let us set up some regressions:

$$\text{Regression of interest: } Y_i = \alpha + \beta D_i + e_i$$

$$\text{First stage: } D_i = \alpha_1 + \gamma Z_i + u_i$$

$$\text{Reduced Form: } Y_i = \alpha_2 + \delta Z_i + v_i$$

$$\text{Plug in regression of interest: } Y_i = \alpha + \beta(\alpha_1 + \gamma \cdot Z_i + u_i) + e_i$$

$$\text{Get back reduced form: } = \underbrace{(\alpha + \beta\alpha_1)}_{\alpha_2} + \underbrace{(\beta\gamma)}_{\delta} Z_i + \underbrace{(\beta u_i + e_i)}_{v_i}$$

$$\text{So we see that } \quad \delta = \beta\gamma \Leftrightarrow \beta = \delta/\gamma$$

Interpretation of the IV coefficient

- How do we interpret γ ?

Interpretation of the IV coefficient

- How do we interpret γ ? The average difference in chocolate consumption between those who got a voucher and those who didn't

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Interpretation of the IV coefficient

- How do we interpret γ ? The average difference in chocolate consumption between those who got a voucher and those who didn't
- How do we interpret δ ? The average difference in happiness between those who got a voucher and those who didn't

$$\beta = \frac{\gamma}{\delta} = \frac{E\left[Y_i \mid Z_i = 1\right] - E\left[Y_i \mid Z_i = 0\right]}{E\left[D_i \mid Z_i = 1\right] - E\left[D_i \mid Z_i = 0\right]}$$

IV gives us the treatment effect for the compliers

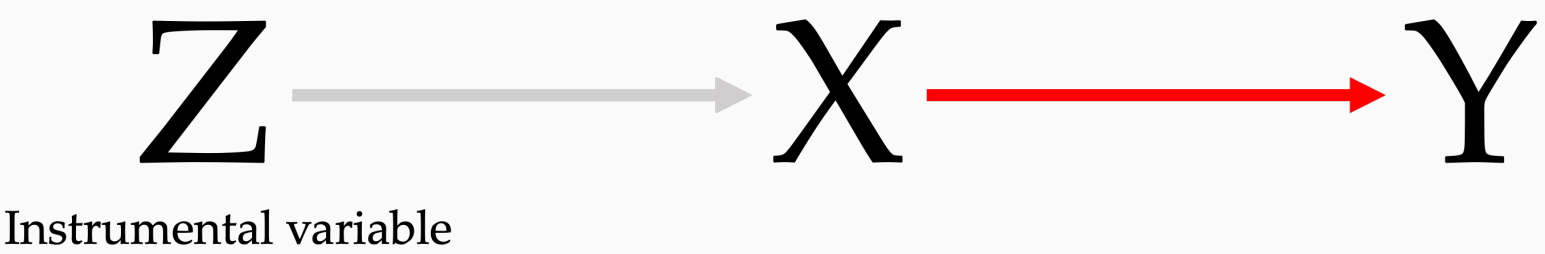
Potential outcomes! (unobserved)		***Does not get voucher (Z=0)***	
Gets voucher (Z=1)		*Eats chocolate (D=1)*	*Does not eat chocolate (D=0)*
	Eats chocolate (D=1)	Always-takers: E(D|Z=1)=E(D|Z=0)=1 ➔ E(Y|Z=1)=E(Y|Z=0)	Compliers
	Does not eat chocolate (D=0)	Defiers	Never-takers: E(D|Z=1)=E(D|Z=0)=0 ➔ E(Y|Z=1)=E(Y|Z=0)

IV Conditions

Does IV always work?

- No! It only works if we have a valid instrument
- For this, we need three conditions:

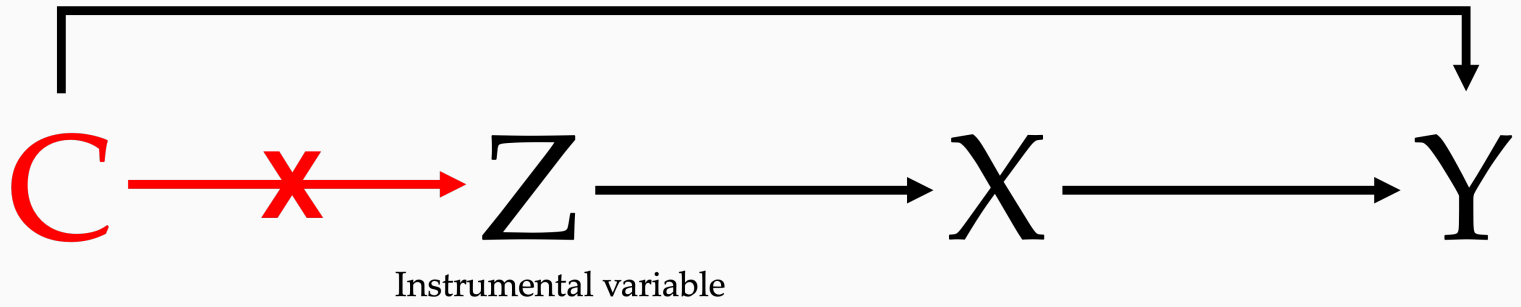
1. Relevance: *Z* must truly affect *X*



Does IV always work?

- No! It only works if we have a valid instrument
- For this, we need three conditions:

2. Independence: *Z* is as good as randomly assigned



Does IV always work?

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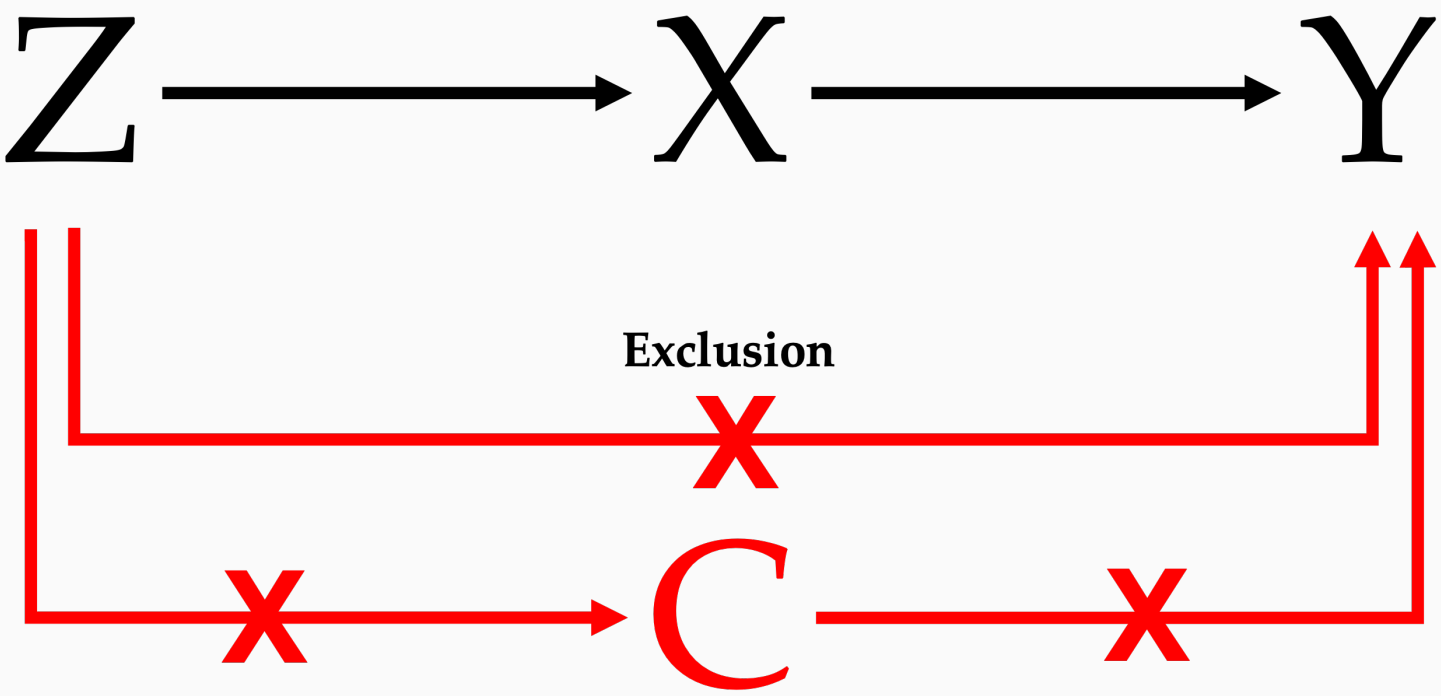
3. Exclusion: The **ONLY** way that *Z* affects *Y* is via *X*!

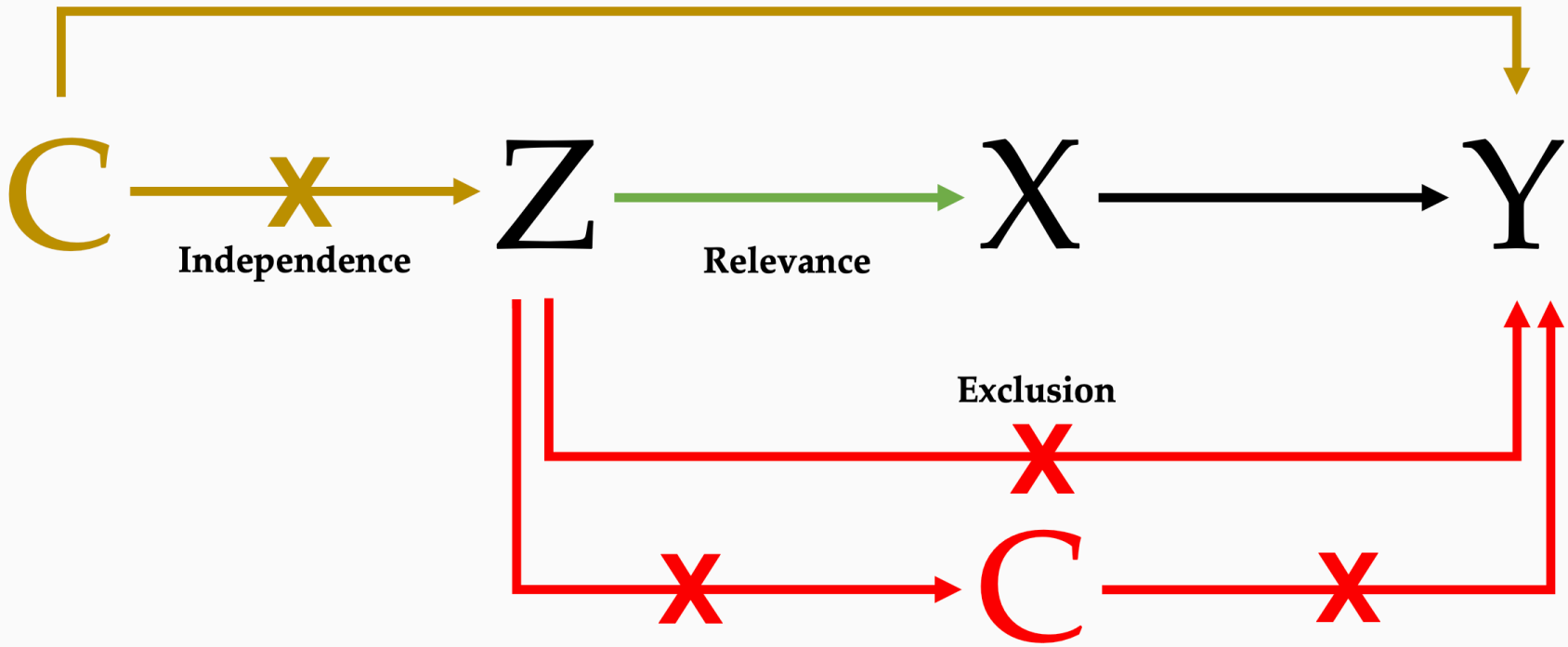


IV Summary

IV summary

We need the following three assumptions for IV to work:

1. **Relevance**: Z must truly affect X
2. **Independence**: Z is as good as randomly assigned
3. **Exclusion Restriction**: The **only** way that Z affects Y is via X.



Any questions?

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Group work

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Group 1: We are interested in the effect of being in the army on crime. We instrument being in the army with a lottery (paper)

Group 2: We are interested in the effect of income on conflict. We instrument income with rainfall (paper)

Group 3: We are interested in the effect of air pollution on mortality. We instrument local air pollution with wind direction (paper)

1. Relevance: Z must truly affect X
2. Independence: Z is as good as randomly assigned
3. Exclusion restriction: The **only** way that Z affects Y is via X

Your job: Discuss whether these assumptions hold!

Any questions?

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Section Assignment

In R

See code in R!