Study designs and statistical methods for current observational studies

2. Instrumental variable analysis

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Study designs and statistical analysis in current observational studies

1. Difference-in-Differences
2. Instrumental Variable Analysis
3. Regression Discontinuity

Natural experimental methods (Quasi-experimental methods)

4. Panel Data Analysis / Interrupted Time-Series

5. Propensity Score Analysis (matching, weighting, stratification, and adjustment using propensity scores)
6. Adjustment(regression), weighting, stratification, and matching

Recap: Difference-in-Differences design

Key assumptions

1. **Parallel trends assumption**

If there is no intervention, the outcomes of the treatment and control group would be a parallel trend.

Demonstrate that the outcomes of the treatment and control groups are parallel at several time points before the intervention.

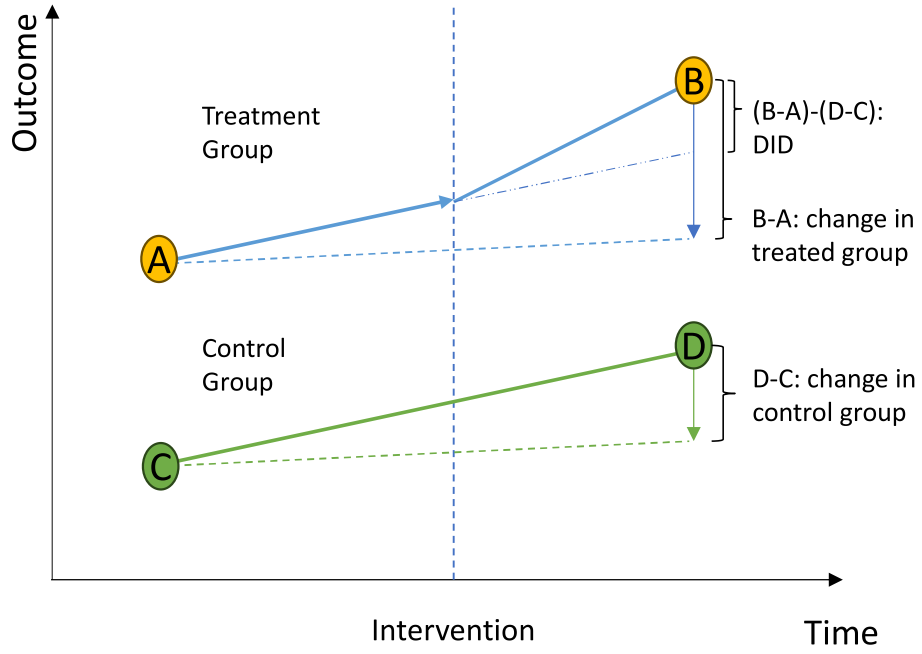
2. **Common shocks assumption**

There are no other exogenous events occurring that affect pre- and post-intervention outcomes, or if they occur, they affect the two groups in the same way.

DID

= (change in treatment) – (change in control)

= ($Treat^{After}$ - $Treat^{Before}$) – ($Control^{After}$ - $Control^{Before}$)



	Treatment	**Control**
Before	A	C
After	B	D
Change	B-A	D-C
DID	(B-A) – (D-C)	

Instrumental Variable Analysis (IV)

Textbook

Wooldridge MJ. Introductory Econometrics: A Modern Approach. 2019

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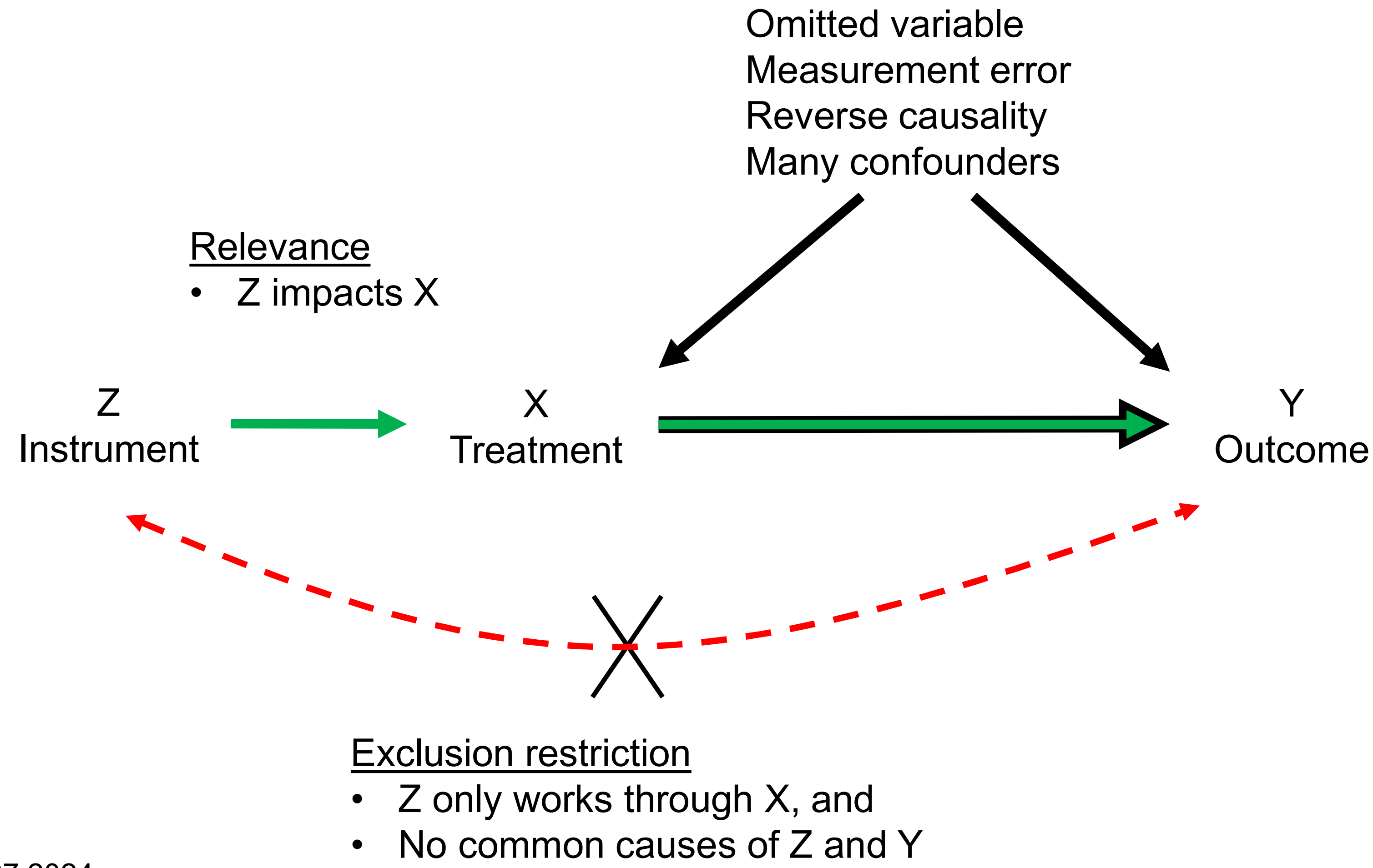
The IV idea



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Key IV assumptions

Relevance

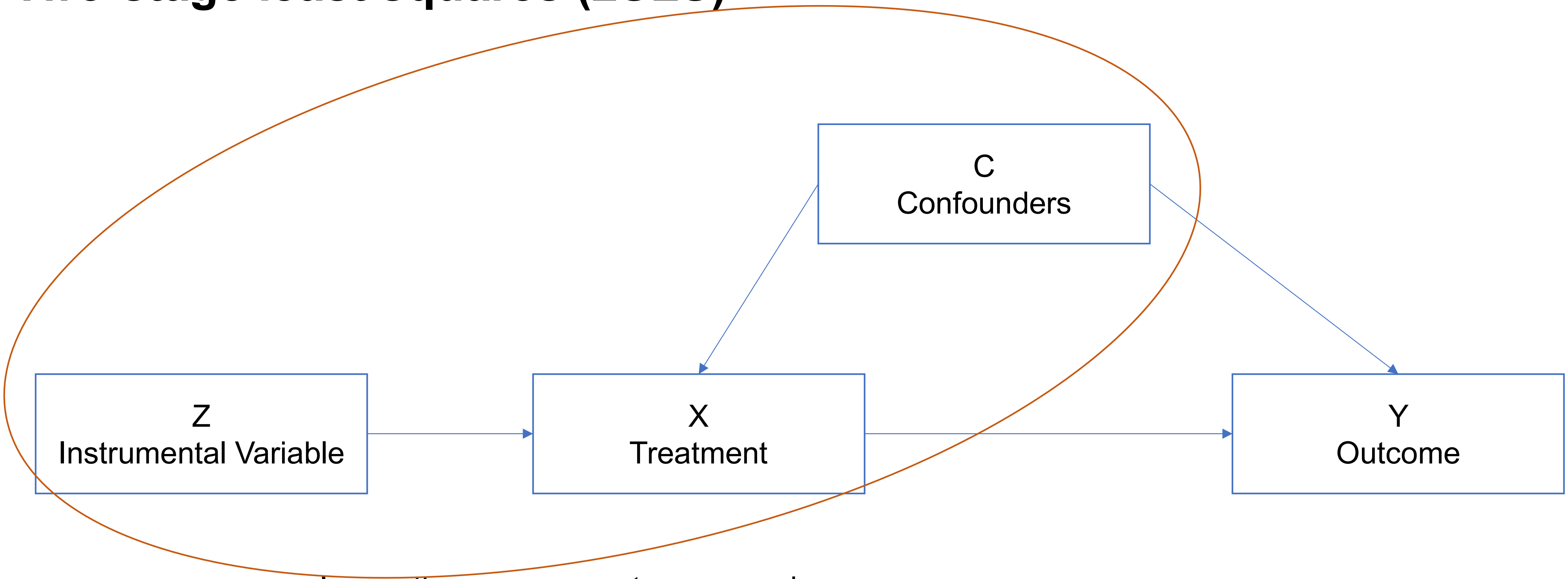
- The instrument Z is “strongly” correlated with the treatment status X: $\mathrm{cov}(X_i, Z_i) \neq 0$
- That is, **Z explains a significant part of the variation in treatment variable X** *once we control for all other factors in our empirical model*

Exclusion restriction

- Z is not correlated with the error term in the main regression: $\mathrm{cov}(Z_i, \varepsilon_i) = 0$

- The instrument must <u>not</u> have a direct causal effect on Y, and can also not be correlated with any other unobserved determinant of Y: it must be orthogonal to the residual
- Said differently: **the instrument Z affects outcome Y <u>only</u> through the relation of Z on X**
- Because of this, we can legitimately exclude the instrument from the regression

Two-stage least squares (2SLS)

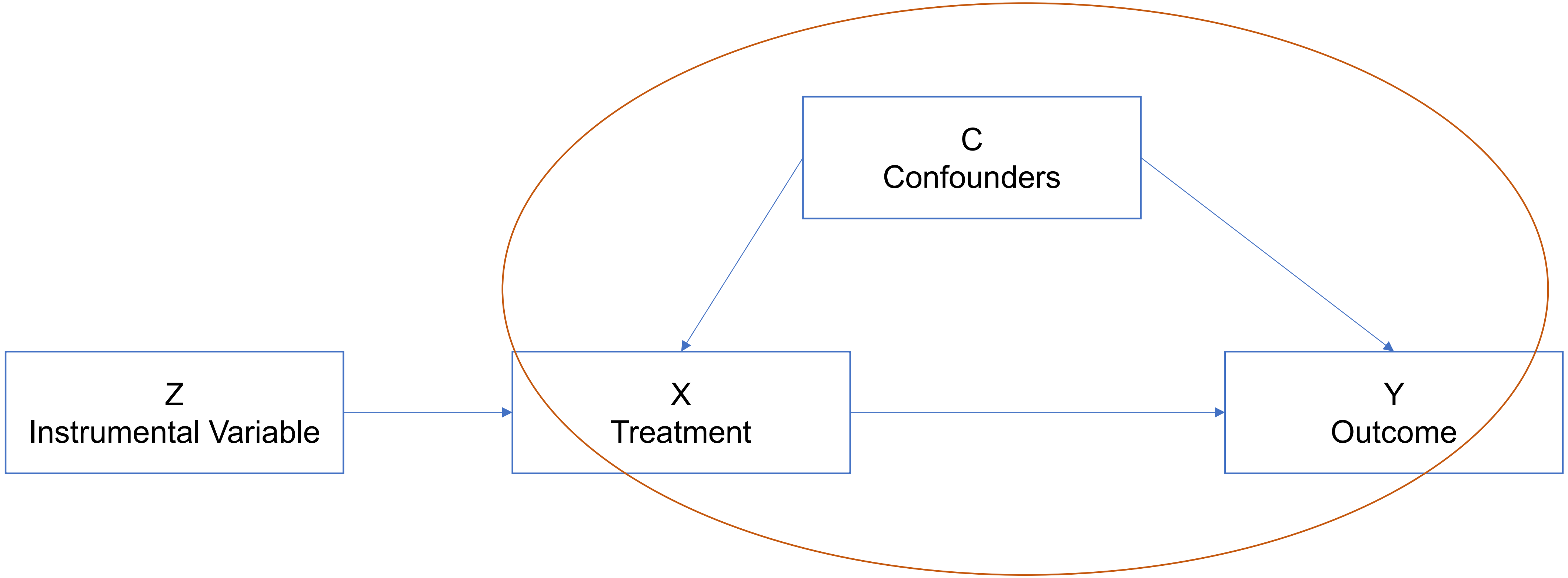


- In practice we can use two regressions :

First-stage: estimate effect of instrument Z on treatment X $X_i = \theta + \gamma Z_i + u_i$

Use this to predict the treatment status $\hat{X}_i$ for different values of Z

Two-stage least squares (2SLS)



- Second-stage: estimate effect of predicted status $\hat{X}_i$ on outcome Y

$$Y_i = \pi + \mu \hat{X}_i + \eta_i$$

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Continued only for students