Natural Experiments and Instrumental Variable Design

Michael Withers

Texas A&M University

MAYS BUSINESS SCHOOL
TEXAS A&M UNIVERSITY

Two broad views of natural experiment design

- Natural exogenous interventions

- Naturally generated instruments

(Cameron & Trivedi, 2005)

Natural exogenous interventions

- Variation derived from an exogenous change or shock
- The intervention is assumed to be assigned at random or as-if random (Dunning, 2012)
- "Good natural experiments are studies in which there is a transparent exogenous source of variation in the explanatory variables that determine the treatment assignment" (Meyer, 1995: 151)
- Addresses potential endogeneity by producing exogenous variation in the main explanatory variables
- Research question: How does an exogenous intervention influence a focal outcome?
- Typically seen in strategic management research:
  - "We are able to mitigate endogeneity issues by testing our theory with a natural experiment."

Naturally generated instruments

- Helps address a major issue with the IV approach (e.g., Angrist & Krueger, 2001; Cameron & Trivedi, 2005; Wooldridge, 2002, 2009):
  - Where do you find good instruments?
- "The ideal instrument" (Larcker & Rusticus, 2010: 197)
- Seeks to also take advantage of exogenous source of variation, but in a different way (Angrist & Krueger, 2001)
- Research question: How does a potentially endogenous variable influence a focal outcome?
- "Units are assigned at random or as-if at random, not to the key independent variable of interest, but rather to this instrumental variable" (Dunning, 2012: 87)
- Not as typically seen in strategic management research

Endogeneity

- Endogeneity occurs when an independent variable is correlated with the error term in a statistical model

- The basic OLS regression model is:

$$y_i = \alpha + \beta x_i + \varepsilon_i$$

- Endogeneity may derive from:
  - Measurement error
  - Simultaneous causality
  - Sample Selection
  - Omitted variable

Campbell's threats to validity in econometric terms

Threats to internal validity	Threats to external validity
• Omitted variables • Trends in outcomes • Misspecified variances • Mismeasurement • Political economy • Simultaneity • Selection • Attrition • Omitted interactions	• Interaction of selection and treatment • Interaction of setting and treatment • Interaction of history and treatment

(Meyer, 1995)

Example: Omitting ability when examining the effect of years of schooling on earnings (Angrist & Krueger, 1991)

$$earnings = \beta_0 + \beta_1 schooling + \beta_2 ability + \mu$$

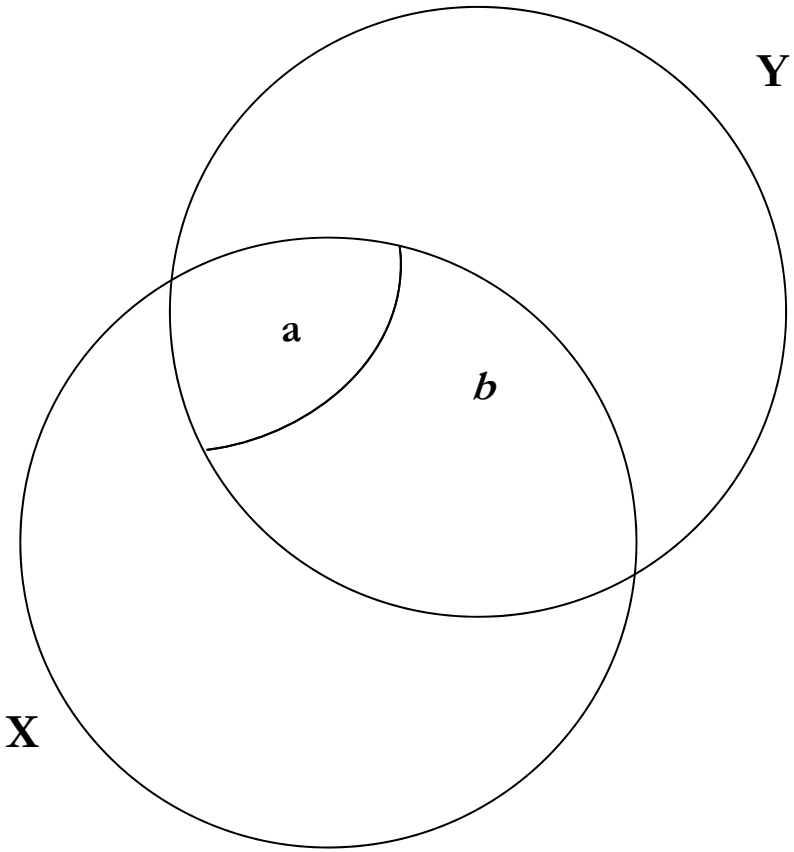
$$ability = \delta_0 + \delta_1 schooling + \vartheta$$

Will both be positive

$$earnings = (\beta_0 + \beta_2\delta_0) + (\beta_1 + \beta_2\delta_1) + (\beta_2\vartheta + \mu)$$

The return to schooling β_1 will be overestimated because $\beta_2\delta_1 > 0$. It will look as if individuals with more years of schooing earn very high wages, but this is partly due to the fact that these individuals with more schooling are also more able on average

A Ballantine illustration

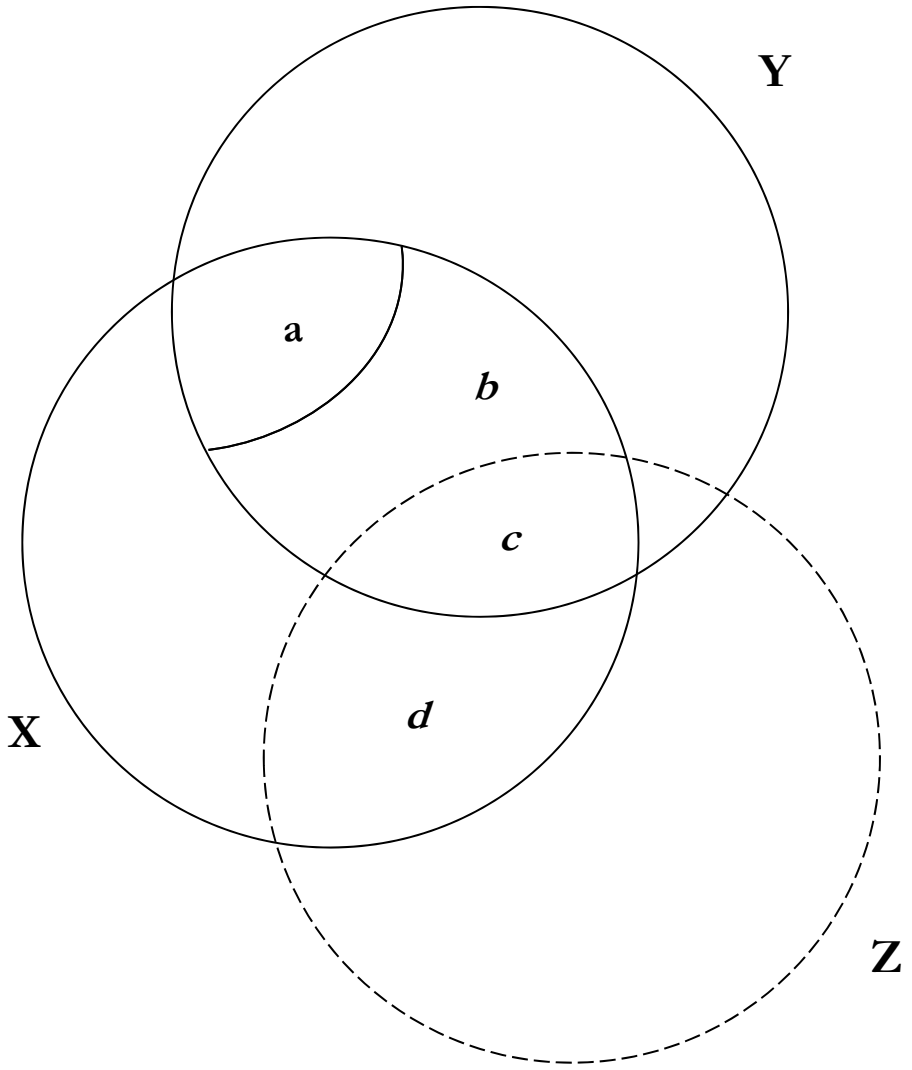


- Back to the basic regression equation:

$$y_i = \alpha + \beta x_i + \varepsilon_i$$

- Circles Y and X represent variation y_i and x_i, respectively
- The area **a** + **b** represent the overlap in variation between Y and X
- However, the area **a** represent overlap in variation between X (x_i), the error term (ε_i), and Y(y_i)
- If Y were regressed on X, the info in the a + b would be used to estimate βx_i.
- This estimate is biased (Kennedy, 2008)

A Ballantine illustration



- The Z variable represents an exogenous shock
- Suppose X is regressed on Z. The predicted area, $\hat{X}$, is represented by the c + d area
- Now regress Y on $\hat{X}$ to produce an estimate of βx_i
- In this case, area c is only used to form the estimate
- Since area c corresponds to variation in Y arising from variation in X, the resulting estimate of βx_i is unbiased.

An IV approach to years of schooling on earnings

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 \cdots + \beta_{k-1} x_{k-1} + \varepsilon_i$$

Schooling variable that is suspected to be endogenous

The endogenous explanatory variable x_1 is predicted using only exogenous information

First stage (= reduced form regression):

$$\hat{x}_1 = \hat{\alpha} + \hat{\alpha}_1 x_2 \cdots + \hat{\alpha}_{k-1} x_{k-1} + \hat{\alpha}_k z_k$$

Exogenous variable = quarter-of-birth using age-based school enrollment laws

Second stage (= OLS with x_1 replaced by its prediction from the first stage):

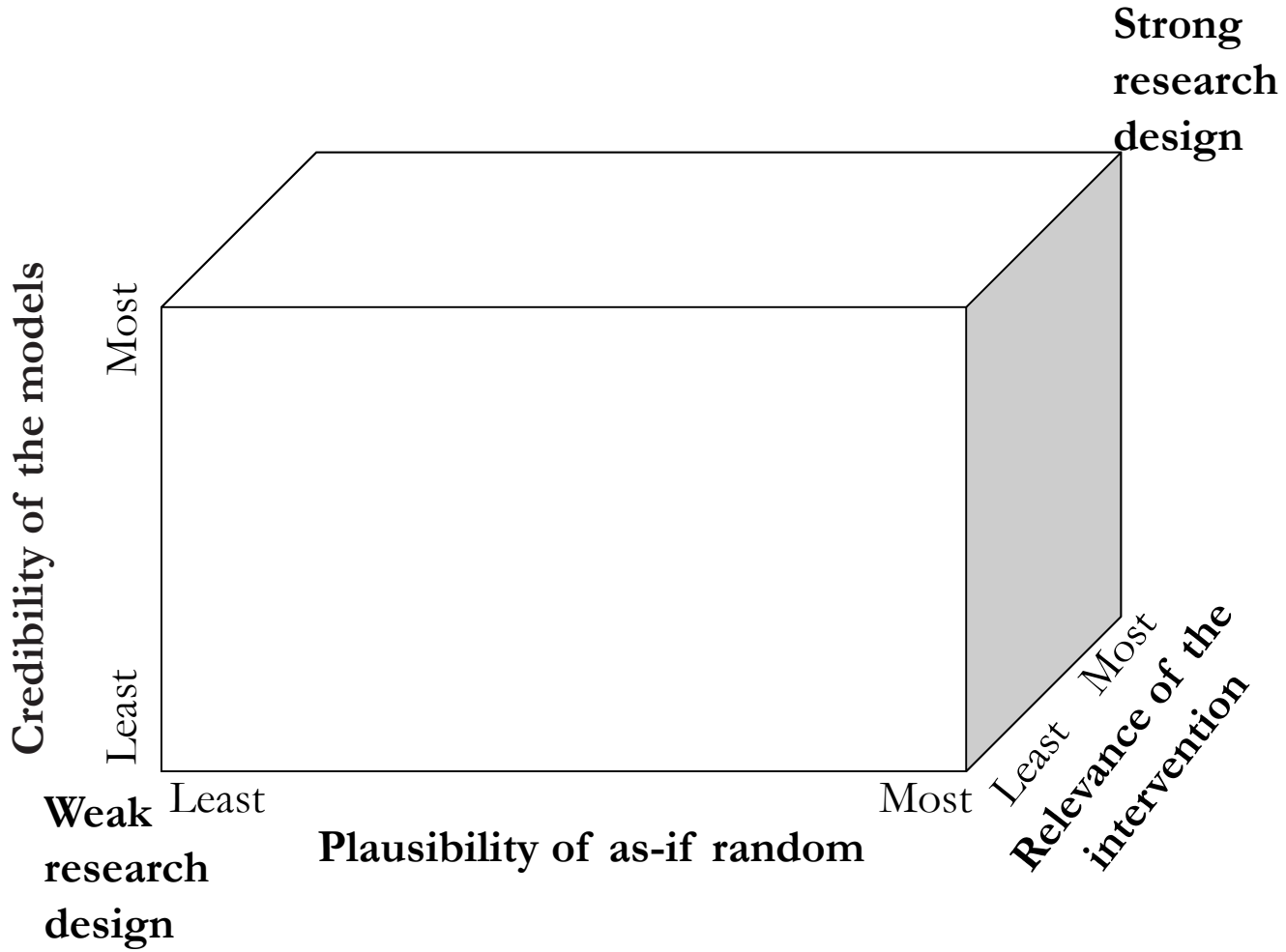
$$y = \alpha + \beta_1 \hat{x}_1 + \beta_2 x_2 \cdots + \beta_{k-1} x_{k-1} + \varepsilon_i$$

Intuition: The ***predicted value*** is the value of the endogenous variable as a function of the exogenous, naturally generated instrument. This isolates the variance in the endogenous variable that is exogenous.

Recommendations for natural experiments as instruments

- Standard natural-experimental or IV design depends on RQ
- Keep in mind the assumptions that underlie both:
  - Plausibility of as-if random and relevance of intervention (Dunning, 2012)
  - Exogeneity and relevance of instruments (Wooldridge, 2002)

Typology of natural experiments



Adopted from Dunning (2012)

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- Some empirical tests can be performed to test assumptions:
  - e.g., Test to show the exogenous intervention is uncorrelated with pre-treatment covariates
  - Report IV regression without other covariates (Dunning, 2012)
- Evidence and reasoning are needed
- When considering a natural experiment as a potential instrument "detailed institutional knowledge and the careful investigation and quantification of the forces at work in a particular setting" are critical (Angrist & Krueger, 2001: 83)

Thank You!

Questions?