Instrumental Variables

28 april

Outline

1. Review matching
2. Instrumental Variables
3. Regression discontinuity designs

"Backdoor criterion"

How do we know what variables to condition on?

1. Condition a "fork of mutual dependence" (i.e., confounds)
2. Condition on a complete chain of mediation
3. Do not condition on "colliders" or their descendents

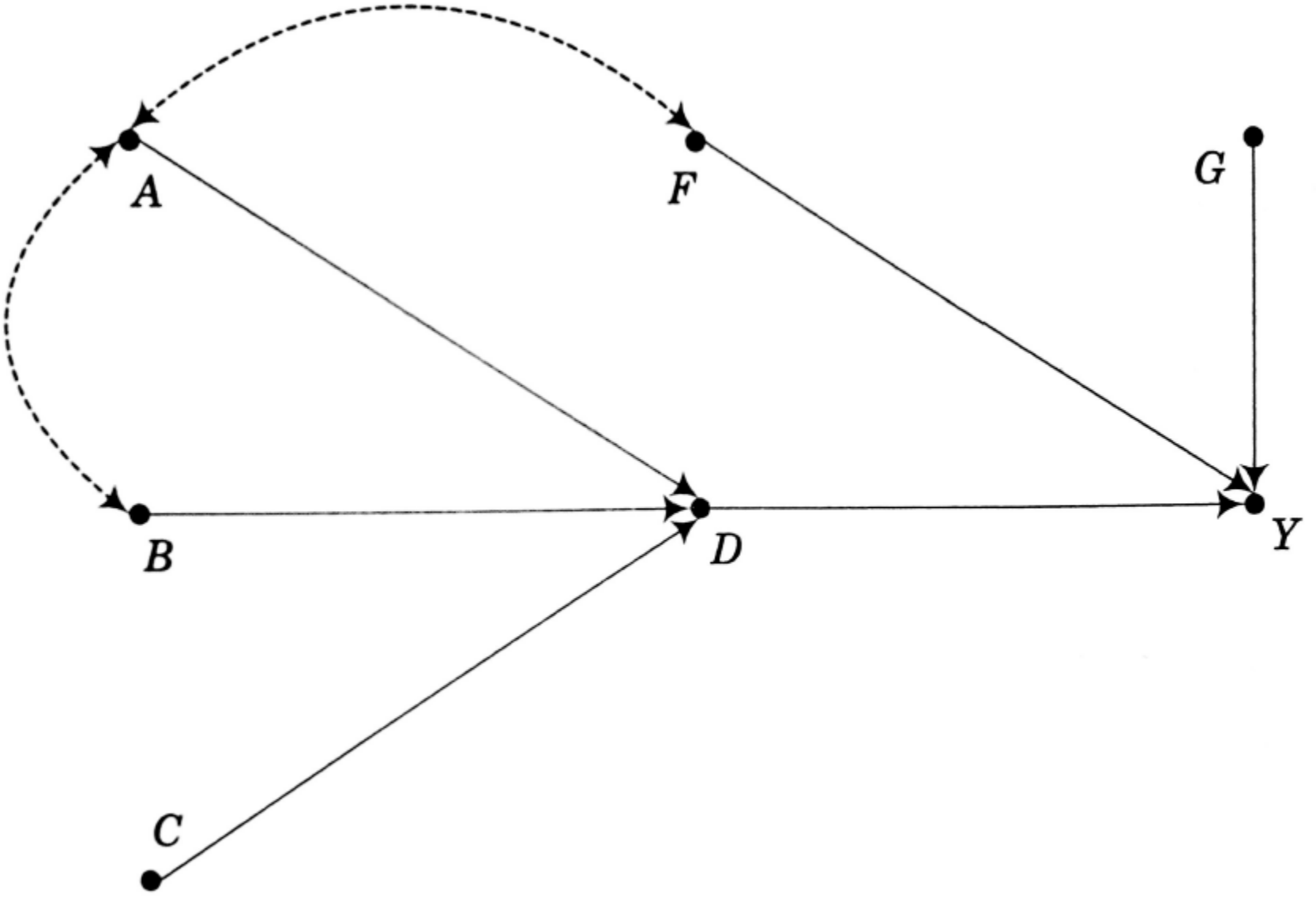
Another strategy:

- Instruments

We'll cover this in Week 12

When do we use instrumental variables?

1. Measurement error
2. Confounding with unobservables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IV in Political Science

- Widely used in economics
- Increasingly common in political science, but still rare
- Especially common in experimental research

Sovey and Green (AJPS, 2010)

Carrubba (2001)

- What is his argument?

Carrubba (2001)

- What is his argument?
- Draw a causal graph of his causal argument.

Carrubba (2001)

- What is his argument?
- Draw a causal graph of his causal argument.
- Share with the person sitting next to you.

Instruments

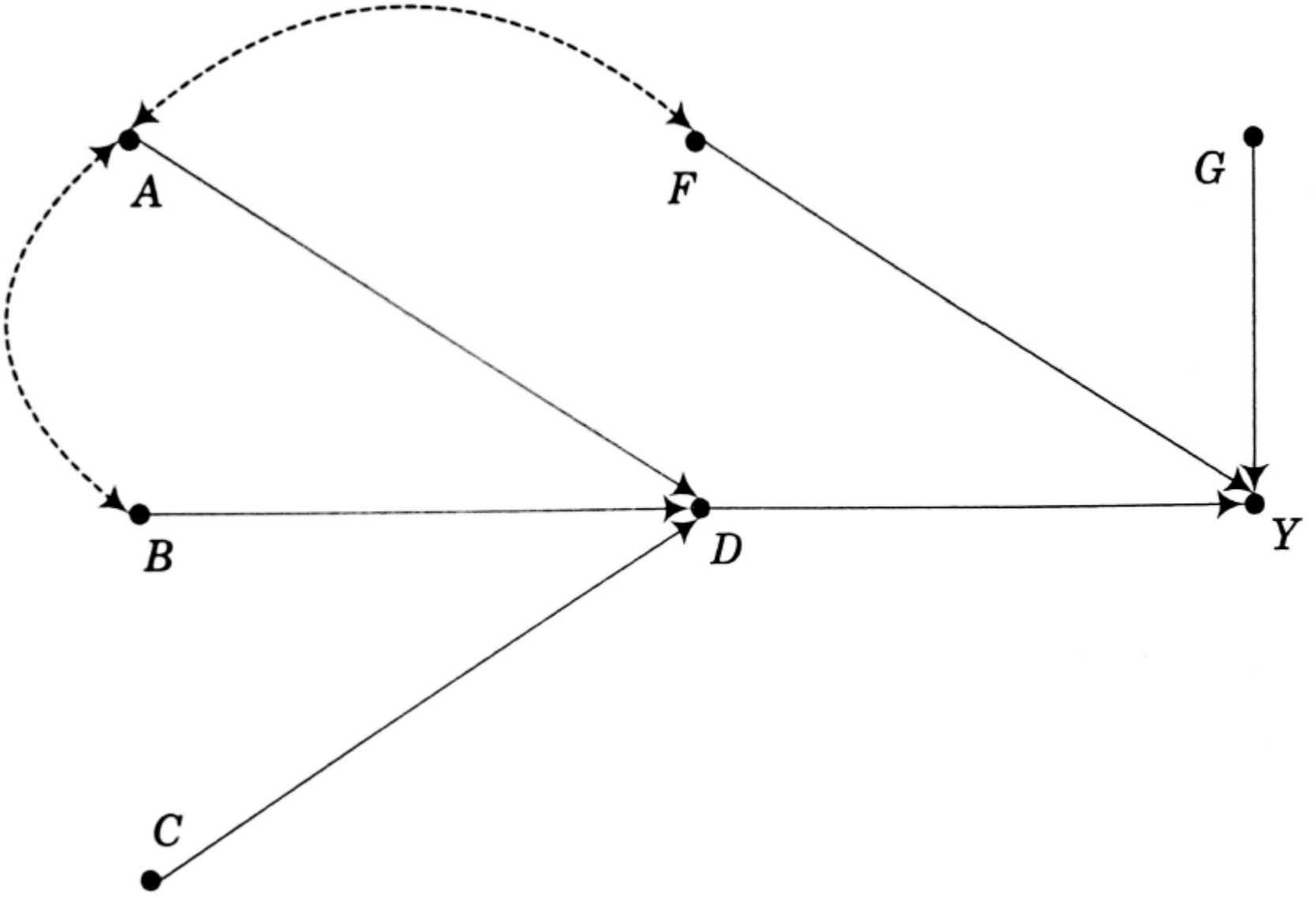
Instruments have to satisfy two properties:

1. Exogeneity
2. Relevance

Instruments

Instruments have to satisfy two properties:

1. Exogeneity
    - Z temporally precedes X
    - $Cov(Z, \epsilon) = 0$
2. Relevance
    - Z related to X
    - $Cov(Z, X) \neq 0$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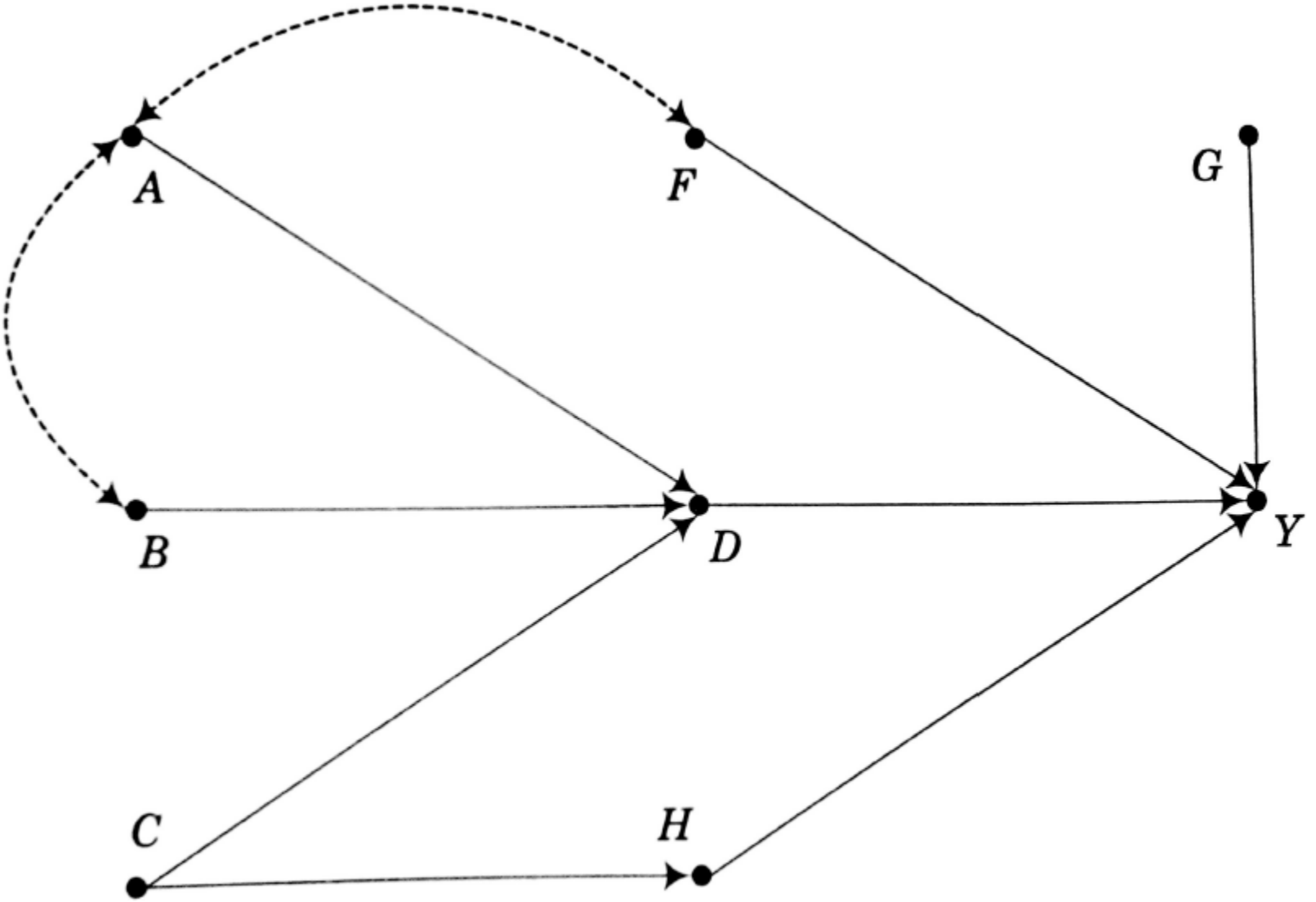
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Instruments

- Exogeneity is not testable

Instruments

- Exogeneity is not testable
- Relevance is testable

Questions?

Carrubba (2001)

- What are Carrubba's instruments?

Carrubba (2001)

- What are Carrubba's instruments?
- Are they relevant?

Carrubba (2001)

- What are Carrubba's instruments?
- Are they relevant?
- Are they exogenous?

IV Estimation

- Several ways to estimate IV model
- We'll focus on Two-Stage Least Squares (2SLS)

Two-Stage Least Squares

- $Y = \beta_0 + \beta_1 X_{Confounded} + \epsilon$
- Estimate of β_1 is biased

Two-Stage Least Squares

- $Y = \beta_0 + \beta_1 X_{Confounded} + \epsilon$
- Estimate of β_1 is biased
- $X_{Confounded} = \rho_0 + \rho_1 Z_{Instrument} + \nu$
- $Y = \beta_0 + \beta_1^{2SLS} \hat{X} + \epsilon$

2SLS IV Estimation in Stata

```
quietly reg endogenous instrument
predict fitted

* simple estimation
reg outcome fitted

* estimation with additional covariates
reg outcome fitted covariates
```

Standard Errors

- Standard errors for IV estimates need to incorporate variance in Z
- So, the doing 2SLS manually produces incorrect SEs
- Luckily, `ivregress` provides functionality directly:

```
ivregress 2sls outcome covariates (confounded = instrument)

* option 'first' gives additional output
ivregress 2sls outcome covariates (confounded = instrument), first
```

Discrete outcomes

Binary outcome:

```
ivprobit outcome covariates (confounded = instrument)
```

Count outcome:

```
ivpoisson gmm outcome covariates (confounded = instrument)
```

Note: `gmm` is an alternative estimation method to 2SLS.

Standard Errors

- SEs are going to be larger in 2SLS than OLS
- We can still use heteroskedasticity-consistent SEs in second stage

An Aside

- Imagine the confounded variable X is an 0/1 indicator
- Should we use logit/probit to estimate the first stage equation?

Questions?

Assessing IV models

- We can assess IV fit in the same way as in OLS
    - Goodness of fit in first stage (relevance)
    - Goodness of fit in second stage

First stage fit in Stata

```
* full first stage results
ivregress 2sls outcome covariates (confounded = instrument), first

* additional first stage fit statistics
estat firststage
```

Assessing IV models

- We can assess IV fit in the same way as in OLS
  - Goodness of fit in first stage (relevance)
  - Goodness of fit in second stage
- Testing for confounding
  - Durbin-Wu-Hausman Test

DWH Test in Stata

- Do residuals from the first stage relate to the outcome?
  - $Y = \beta_0 + \beta_1 X_{Confounded} + \beta_2 \nu + \epsilon$
  - ν are the residuals from the first stage
- In Stata:

```
quietly ivregress 2sls outcome covariates (confounded = instrument)
estat endogenous
```

Questions?

How many instruments?

1. Exactly identified
    - Same number of instruments as confounded variables
2. Overidentified
    - More instruments than confounded variables
3. Underidentified
    - Fewer instruments than confounded variables

Overidentifying restrictions

- With multiple instruments we can evaluate a null hypothesis that all instruments are valid
- Rejection of the null implies that at least one of the instruments is invalid
- Failure to reject implies nothing
- In Stata:

```
quietly ivregress 2sls outcome covariates (confounded = instrument)
estat overid
```

Instruments versus treatments

- How does an instrument differ from a treatment variable?
- In other words, if instruments are so good why don't we just look at their direct effects on Y?

IV Checklist

1. How/why is the instrument exogenous?
2. How strong is the instrument?
3. Are there other possible instruments?

Sovey and Green (AJPS, 2010)

Questions?

Activity

- List of instruments used in published literature
- Assess credibility of the instruments

Forward vs. Backward Causal Inference

- Forward causal inference
- Backward causal inference

Questions?

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Effect Heterogeneity

- Esimation of any effect is more difficult if we think effects vary across units
- But we can estimate a Local Average Treatment Effect (LATE)
- This only applies to "compliers"

Four subpopulations

Imagine a binary X and a binary instrument Z

- Compliers: $X = 1$ only if $Z = 1$
- Always-takers: $X = 1$ regardless of Z
- Never-takers: $X = 0$ regardless of Z
- Defiers: $X = 1$ only if $Z = 0$

Estimating LATE

- Intention-to-treat effect (ITT)
  - $E[Y|Z=1] - E[Y|Z=0]$

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- Intention-to-treat effect (ITT)
  - $E[Y|Z=1] - E[Y|Z=0]$
- Estimated proportion of compliers ($\pi_Compliers$)
  - $Pr(X=1|Z=1) - Pr(X=1|Z=0)$

Estimating LATE

- Intention-to-treat effect (ITT)
  - $E[Y|Z=1] - E[Y|Z=0]$
- Estimated proportion of compliers ($\pi_Compliers$)
  - $Pr(X=1|Z=1) - Pr(X=1|Z=0)$
- Result: $LATE = \frac{ITT}{\pi_Compliers}$

Questions?

Stop and think

- Are the SATE (ATE for whole sample) and LATE (ATE for compliers) the same?
- Do we care about the LATE? If so, why? What inferences can we make from it?

Aside: Experimentation

- Earlier, we noted that IV is common in experimental research
- Experiments often involve noncompliance
    - Some individuals do not take the treatment they are assigned
- IV allows us to estimate the LATE for those who comply with treatment
- Useful for both true experiments and "natural experiments"

Nearly random instruments

- Draft (conscription) lotteries
- Geographical boundaries
- Weather
- Natural disasters

"Sharp" and "Fuzzy" discontinuities

- If an instrument imperfectly causes X, then it produces a fuzzy discontinuity
- If an instrument perfectly causes X, then it produces a sharp discontinuity

Example: Maimonides' Rule

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Example: Maimonides' Rule

- What is Maimonides' Rule?
- Why is it a valid (credible) instrument? (Or why isn't it?)
- How does it differ from a randomized experiment?

Problems with discontinuities

- Compensatory rivalry & equalization
- Campbell's Law:

> The more any quantitative social indicator (or even some qualitative indicator) is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it is intended to monitor.

Questions?

Preview

- Tomorrow:
  - IV in Stata
- Next week:
  - Missing Data