Lecture 6:
Instrumental Variables, 2 of 2

February 19, 2025

Course Administration

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2. Lab after class today
3. If you still need approval for your replication paper, I am nervous
4. Problem Set 3 due March 5

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4. Problem Set 3 due March 5
5. Quantitative summary
   - Discuss handout
   - Due March 19
6. Please come see me about your replication paper
7. Any other issues?

Today

IV Background

1. IV how-to
2. Bound, Baker and Jaeger critique of Angrist & Krueger
3. IV as a local average treatment effect

Evaluating Papers

1. Research question and endogeneity concerns
2. Data
3. Specification and instrument
4. Instrument validity
5. Results and interpret coefficients, LATE

IV: Basic Rules of Engagement

IV Regression Steps

We want to estimate $Y = \beta X + \sigma C + \epsilon$, but X is endogenous.

Steps

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   $X = \gamma Z + \alpha C + \delta$
   Z are instruments and C are covariates

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Rules

1. Covariates from second stage must be in first stage
2. Stata and other software automatically pass $\hat{X}$ to the second stage
3. F value for assessing instrument strength is from Z in first stage
4. Incremental R^2 that tells about instrument strength comes from comparing R^2 in
   $X = \gamma Z + \alpha C + \delta$
   versus
   $X = \alpha C + \delta$

BBJ on A&K

Recall the Two Key IV Assumptions

Instrument is

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Instrument is

1. correlated with endogenous variable
   $cov(X, Z) \neq 0$
2. correlated with dependent variable only through relationship with endogenous variable
   $cov(Z, \epsilon) = 0$

The Bound/Baker/Jaeger Critique

Journal of the American Statistical Association, 1995

Relative consistency of IV

$$\frac{\text{plim } \hat{\beta}_{IV} - \beta}{\text{plim } \hat{\beta}_{OLS} - \beta}$$

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Relative consistency of IV

$$\frac{\text{plim } \hat{\beta}_{IV} - \beta}{\text{plim } \hat{\beta}_{OLS} - \beta} = \frac{\rho_{Z,\epsilon}/\rho_{x,\epsilon}}{\rho_{x,Z}}$$

- $\rho_{Z,\epsilon} \sim$ corr btwn Z and ϵ
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- As the correlation between the instrument Z and the endogenous variable X decreases – $\rho_{X,Z}$ gets small
- $\hat{\beta}_{IV}$ becomes more inconsistent relative to OLS
- A small correlation leads to big biases

How Do You Check for This Problem?

- Measure $\rho_{X,Z}$ as the additional R^2 you get when adding instruments to the equation
- "If the relationship between the instruments and the endogenous variable is weak enough, even enormous samples do not eliminate the possibility of quantitatively important finite-sample biases."
- This means look carefully at first stage F stats, and partial R^2
- In addition, finite sample bias of $\hat{\beta}_{IV}$ increases in number of instruments, all else equal

Applying This to A&K

- A and K don't have first stage tables in their paper; they argue for instrument relevance, but not for strength
- In most complete specification. they have QOB*year of birth + QOB*state $= 3 * 10 + 3 * 50 = 180$ instruments
- Also, QOB may affect wages through pathways other than years of schooling (from BBJ)
  - school performance
  - likelihood of behavioral difficulties
  - likelihood of referral to mental health services
  - etc, etc ...
- Now people just use the laws themselves, not quarter of birth

Suppose Quarter of Birth is Garbage – Then What?

- Original paper, T4, cols 4 and 5 (parallel to 1)
  - $\hat{\beta}_{OLS} = 0.0701$
  - $\hat{\beta}_{IV} = 0.0669$
- make a random quarter of birth for each person
- regress this fake quarter of birth on education
- make predicted values
- do second stage
- repeat 1000 times
- find mean of $\hat{\beta_{IV}}$

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Table 3. Estimated Effect of Completed Years of Education on Men's Log Weekly Earnings, Using Simulated Quarter of Birth (500 replications)

Table (column)	1 (4)	1 (6)	2 (2)	2 (4)
	Estimated Coefficient			
Mean	.062	.061	.060	.060
Standard deviation of mean	.038	.039	.015	.015
5th percentile	−.001	−.002	.034	.035
Median	.061	.061	.060	.060
95th percentile	.119	.127	.083	.082
	Estimated Standard Error			
Mean	.037	.039	.015	.015

NOTE: Calculated from the 5% Public-Use Sample of the 1980 U.S. Census for men born 1930–1939. Sample size is 329,509.

Bottom Line: What Do You Do?

- It is now standard to report F statistics for instruments
- If they are not approximately 10 or greater, become worried
- Use the incremental R^2 to explore instrument strength
- All else equal, use fewer instruments

IV: LATE

A Framework for Understanding IV Estimates

Interpreting IV as a Local Average Treatment

Let's return to the potential outcomes notation

- Outcome if treated: Y_{1i}
- Outcome if not treated: Y_{0i}
- Dichotomous treatment: D_i
- For any person, we observe only $Y_i = Y_{0i} + D_i(Y_{1i} - Y_{0i})$

- We are usually interested in
  - the ATE ($E(Y_{1i} - Y_{0i})$)

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- We are usually interested in
  - the ATE ($E(Y_{1i} - Y_{0i})$) or
  - the ATET ($E(Y_{1i} - Y_{0i}|D_i = 1)$)
- In what sense is this average?
- In the the Black et al paper, think of the effect of siblings on earnings (β) as a weighted average of the effect at different numbers of siblings, where the weights are the share of the different size of sibling groups

With thanks to these sources (one and two).

Assume a Constant Treatment Effect of IV

- In general in IV, we assume that there is a constant treatment effect: $Y_{1i} - Y_{0i} = \alpha$
- You don't need this for standard OLS regression
- Let Z be a dichotomous instrument
- Then we can re-write the Wald estimator in this framework as

$$\frac{E(Y_i|Z_i = 1) - E(Y_i|Z_i = 0)}{E(X_i|Z_i = 1) - E(X_i|Z_i = 0)} = \alpha$$

- Think of examples where the treatment effect is not constant!

Defining the local average treatment effect

- When the treatment effect is not constant, IV captures neither ATE nor ATET
- Any guesses why?

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Defining the local average treatment effect

- When the treatment effect is not constant, IV captures neither ATE nor ATET
- Any guesses why? intuitively only some portion of the population is influenced by the instrument. Examples?
- Think of three types of people whose behavior could be influenced by the instrument
  - never-takers: no matter what, this person won't accept treatment
  - compliers: take treatment because of instrument
  - always-takers: always take treatment no matter what
  - defiers: they don't do what the instrument says

Making Cases for Potential Effect of Instrument

		Merge = 0	
		Same No. Banks	Fewer Banks
Merge = 1	Same No. Banks	never-taker	defier
	Fewer Banks	complier	always-taker

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		Rain = 0	
		No Riot	Riot
Rain = 1	No Riot	never-taker	defier
	Riot	complier	always-taker

Intepreting IV Estimate as Effect of Treatment on Compliers

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  - instruments are "as good as randomly assigned,"
  - or that Z affects Y only through D

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- Monotonicity
  - Either $D_{1i} \geq D_{0i}$ for all i or vice versa
  - "Monotonicity requires that, while the instrument might have no effect on some individuals, all of those who are affected should be affected in the same way (for example, draft eligibility can only make military service more likely, not less)."
  - Rules out "defiers" in the bottom left and upper right

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Bottom line: powerful way to think about IV results, particularly if you don't find the constant treatment effect compelling.

Lecture 6: Papers to Discuss

Outline for Paper Discussion

1. Research question and endogeneity concerns
2. Data
3. Specification and instrument
4. Instrument validity
5. Results and interpret coefficients, LATE

1. What are the research questions and endogeneity concerns?

What are the Research Questions?

Collins and Margo

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- Do the 1960s riots impact property value?

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Nguyen

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Nguyen

- Does a bank branch closure in a heavily banked market cause declines in lending?
- More generally, does distance matter for economic activity?

Endogeneity Concerns

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- perhaps limited economic activity causes riots – and also decreases home prices
- perhaps better political climate yields no riots, or weaker riots and this leads to economic growth – which increases home prices

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- "The empirical challenge in estimating the local effects of branch closings is that the closing decision is endogenous to local economic conditions that are correlated with credit demand." (p. 3)
- closings should occur in markets where lending is declining – declining lending causes less credit

2. Data

What Data do the Authors Use?

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- panel of tracts 1999-2012, which are neighborhoods of roughly 4,000 people
- includes info on
  - branches by bank per year
  - number and volume of small business and mortgage loans
  - establishment data from NETS
  - demographics from Census 2000
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3. Specification and Instrument

C&M: Specification and Instrument

Second stage

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$$\Delta V_i = \alpha + \beta_1 X_i + \beta_2 \text{region}_i + \beta_3 \text{riot severity}_i + \epsilon_i$$

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C&M: Specification and Instrument

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First stage

$$\text{riot severity}_i = \gamma_1 + \gamma_2 X_i + \gamma_3 \text{region}_i + \gamma_4 \text{rain April 1968}_i + \gamma_5 \text{city manager}_i + \nu_i$$

- Instruments
  - rainfall in April 1968
  - being a council manager-type city

C&M First Stage Results

TABLE 5
RIOT SEVERITY AND INSTRUMENTAL VARIABLES

Dependent Variable	Severity Group (1)	Severity Group (2)	Severity Group (3)	Severity Group (4)	Severity Index (5)
Rainfall, April 1968	–0.109	–0.126	–0.106	–0.0934	–0.0140
	(0.0335)	(0.0404)	(0.0354)	(0.0327)	(0.00539)
Rainfall, annual avg.	—	–0.00588	—	—	—
		(0.00834)			
Rainfall, April avg.	—	0.145	—	—	—
		(0.0938)			
Rainfall, April 1967	—	–0.0375	—	—	—
		(0.0323)			
City manager	–0.229	–0.193	–0.229	—	–0.0250
	(0.140)	(0.146)	(0.141)		(0.0143)
Percentage black	2.68	2.51	2.69	2.95	0.311
	(0.513)	(0.585)	(0.509)	(0.506)	(0.105)
Total population	2.51 e–07	2.54 e–07	2.52 e–07	2.71 e–07	3.57 e–08
	(8.01 e–08)	(8.39 e–08)	(8.01 e–08)	(8.92 e–08)	(2.13 e–08)

No first stage F test in table; text says 5.5

Ngyuen: Specification and Instrument

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$$y_{i,t} = \alpha_i + \gamma_t + \lambda X_{i,t} + \beta_c \text{Close}_{i,t} + \epsilon_{i,t}$$

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- but maybe banks merge to do exactly this! her way of dealing with this

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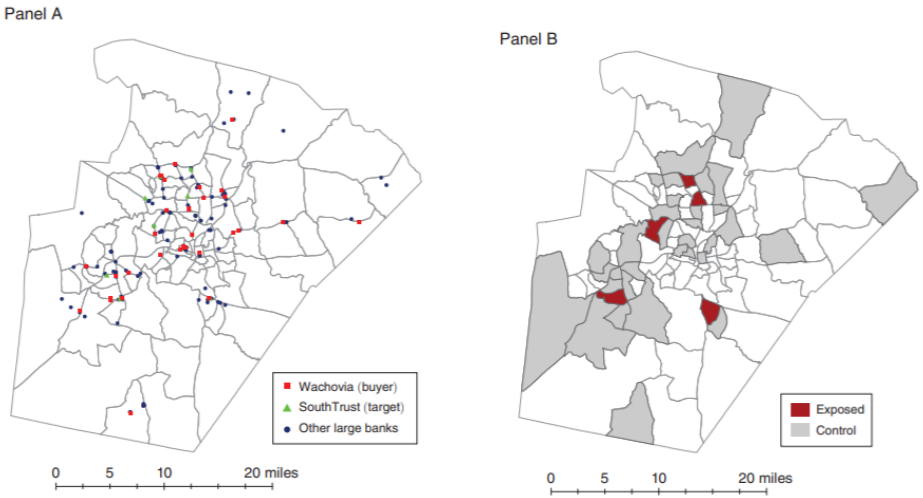
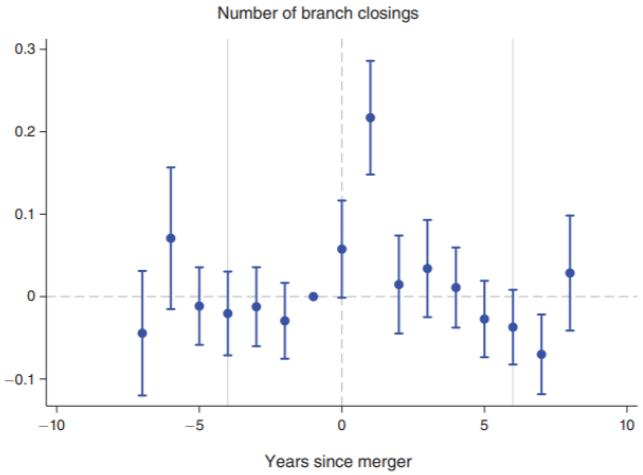
- "exposure" is 1 "if two banks with branches in tract i undergo a merger in year t" (p. 10)
- but maybe banks merge to do exactly this! her way of dealing with this
  - choose only very large mergers, so that retail banking overlap unlikely to be the driving force (1.4% of deposits held in exposed tracts for big mergers)
  - have branches from Buyer and Target banks in the year prior to the merge
  - further limits sample of controls to any tracts that do not have both Buyer or Target banks, but do have at least two large banks that don't merge

What's Going on with the Sample?



First Stage Coefficient of Interest, Sort of: Figure 2

Impact of Merger Exposure on Branch Closure



4. Instrument Validity

C&M: Instrument Validity

What evidence do they marshal to try to convince you that the exclusion restriction ($cov(Z, \epsilon) = 0$) holds?

C&M: Instrument Validity

What evidence do they marshal to try to convince you that the exclusion restriction ($cov(Z, \epsilon) = 0$) holds?

- rainfall in April 1967, average annual rainfall, and average April rainfall not related to riot severity
- here, it is hard to think of a reason April 1968 rainfall matters for property values except through connection to riots (but maybe you had some ideas)
- not much to say on council-manager instrument

Nguyen: Instrument Validity

What evidence does she provide to try to convince you that the exclusion restriction ($cov(Z, \epsilon) = 0$) holds?

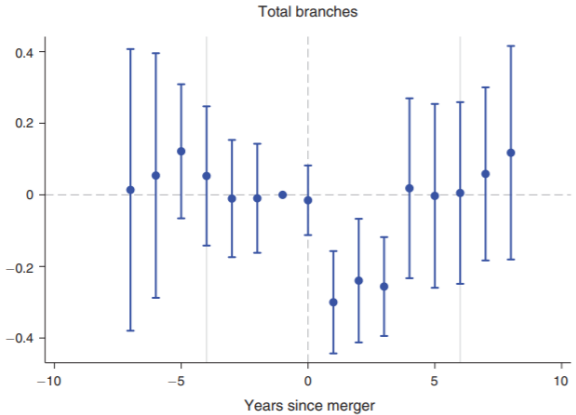
Nguyen: Instrument Validity

What evidence does she provide to try to convince you that the exclusion restriction ($cov(Z, \epsilon) = 0$) holds?

- exposure impacts tract-level outcomes only through impact on closure
- or "the decision to merge is plausibly exogenous with respect to the exposed tracts" (p. 11)
- see Figures 2 and 3

First Stage Coefficient of Interest: Figure 3

Impact of merger on total bank branches



Why include this figure?

First Stage Coefficient of Interest: Figure 3

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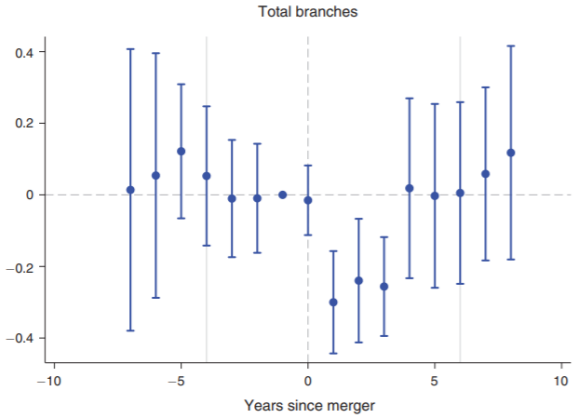

Why include this figure?

- test for pre-trends
- look for net effect on branches

5. Results and LATE Interpretation

C&M: Results

TABLE 6
RIOTS AND BLACK-OWNED PROPERTY VALUES, OLS AND 2SLS ESTIMATES

	1960–1970			1960–1980		
	OLS (1)	2SLS (2)	2SLS (3)	OLS (4)	2SLS (5)	2SLS (6)
Severity group (0–2)	–0.0716 (0.0185)	–0.191 (0.0913)	–0.165 (0.0856)	–0.101 (0.0281)	–0.237 (0.133)	–0.220 (0.129)
Percentage black	0.273 (0.133)	0.593 (0.282)	0.505 (0.265)	–0.186 (0.254)	0.181 (0.435)	0.123 (0.431)
Total population	1.19 e–09 (7.37 e–09)	3.40 e–08 (2.64 e–08)	2.60 e–08 (2.45 e–08)	–1.06 e–08 (1.83 e–08)	2.71 e–08 (3.55 e–08)	2.18 e–08 (3.46 e–08)
Value trend 1950–60	—	—	0.282 (0.106)	—	—	0.172 (0.20)
Northeast	0.0607 (0.0482)	0.141 (0.0768)	0.141 (0.0708)	–0.189 (0.0711)	–0.0967 (0.114)	–0.0979 (0.111)
Midwest	–0.0687 (0.0339)	–0.0014 (0.0637)	–0.0164 (0.0594)	–0.226 (0.0643)	–0.149 (0.100)	–0.159 (0.0980)
West	0.0401 (0.0459)	0.106 (0.0736)	0.0902 (0.0676)	0.247 (0.0726)	0.322 (0.112)	0.312 (0.107)
Constant	0.341 (0.0425)	0.312 (0.0506)	0.223 (0.0593)	1.386 (0.0779)	1.352 (0.0857)	1.298 (0.103)
N	104	104	104	104	104	104

C&M: LATE Interpretation

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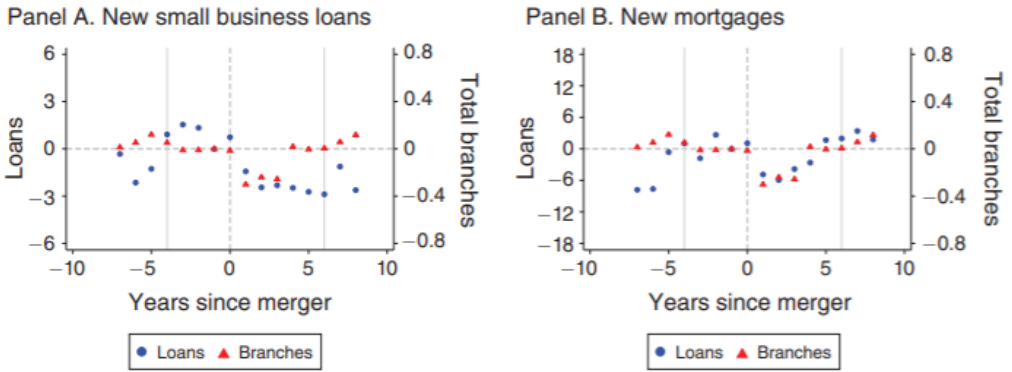
- perhaps implies that cities that are deterred from disturbance by rain are more equal/less angry cities, so those with smaller impacts
- maybe it's more about effects not in California, where it wouldn't rain much anyhow

Nguyen: Results



First stage = red triangles; reduced form = blue dots; Wald estimate = blue/red

Nguyen: Table 7

	Small business loans	
	Number of loans (1)	Dollar volume (000s) (2)
Panel A. OLS		
δ_{OLS}	−2.143	−100.9
	(0.745)	(48.64)
Panel B. RF		
δ_{RF}	−2.513	−206.7
	(0.909)	(77.91)
Panel C. IV		
δ_{IV}	−10.41	−871.4
	(3.738)	(327.9)
Six-year cumulative effect	−62.47	−5,228
	(22.43)	(1,967)
Baseline mean	103.4	4,706
Observations	45,160	43,033

Nguyen: Thinking LATE

Who is impacted by merger as defined in this paper?

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Who is impacted by merger as defined in this paper?

- be cognizant that this is a non-random sample of all tracts
- wealthier, whiter, more loans: see Table 3
- is this likely an under- or over-estimate of the effect of a closure in a 1-branch tract? an underestimate

Anything else?

Next Lecture

- Read
  - *Causal Mixtape* Chapter 6.1, 6.2, but only through 6.2.3
  - Anderson on public transit and traffic
- Summary due next week if you're on the list