

# **ECON 8000/9000 Empirical Energy Econ**

## **Topic 13: Regional Growth and Local Labor Market Effect**

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# Outline

- ▶ Topics in Energy Economics on Regional Growth and Local Labor Market Effect
- ▶ Example 1-2: Previously Covered: Fabra et al. (2024) + Allcott & Keniston (2018)
- ▶ Example 3: Severnini (2022) EJ
- ▶ Example 4: Kahn & Mansur (2013) JPubE
- ▶ Example 5: Muehlenbachs, Spiller, & Timmins (2015) AER
- ▶ Example 6: Yip (2018) JEEM
- ▶ Example 7: Brehm et al. (2025) Working Paper

# Typical Research Questions

## Typical Questions

- ▶ How do local energy shocks affect regional growth and local labor market?
- ▶ How does the energy transition affect the local economy and local labor market?
- ▶ How does the energy resource boom & bust affect the local economy? Do we observe a Dutch disease?
- ▶ How do local energy shocks shift the composition of local industries and local workers? Distributional effect? Zero-sum? Positive-sum?
- ▶ How does the short-term effect compare to the long-term effect?

## Typical shocks studied:

- ▶ Phase-out of coal
- ▶ Shale gas boom
- ▶ Boom & bust of oil industry
- ▶ Uptake in renewables
- ▶ Variation in electricity price on local downstream industries
- ▶ Regulations on the power sector on the local economy and workers

# Typical Methodology

## Typical estimator

- ▶ Panel data methods: TWFE, Event Study, FD estimator
- ▶ Shift-share IVs or shift-share OLS
- ▶ Synthetic control

## Typical unit of observation

- ▶ Usually, these regressions are estimated at a "local labor market" level
- ▶ If data is individual level or establishment level, often researchers aggregate outcomes to a local labor market
- ▶ Typical local labor market:
  - ▶ a municipal (often in European countries)
  - ▶ commuting zone
  - ▶ county
  - ▶ Less often: aggregate obs to a radius or a doughnut area centered around a shock

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# Previously Covered + Student Presentations

## Fabra, Gutierrez, Lacuesta, & Ramo (2024) JPubE:

- ▶ "Do Renewable Energy Investments Create Local Jobs"
- ▶ RQ: Do solar and wind new capacity create jobs in local municipalities in Spain?
- ▶ Approach: LP-DID

## Allcott & Keniston (2018) RES:

- ▶ "Dutch Disease or Agglomeration? The Local Economic Effects of Natural Resource Booms in Modern America"
- ▶ RQ: How have the historical boom & bust of oil industry affect local economy in the US?
- ▶ Approach: Shift-share OLS

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# Severnini (2022) EJ

"The power of hydroelectric dams: Historical evidence from the US over the 20th century"

## Research Question and Data:

- ▶ RQ: How has historical hydro dam construction affect local economy?
- ▶ Focus: Hydro dams constructed since 1910s
- ▶ Data time frame: 1870-2010
- ▶ Data frequency: every 10 years
- ▶ Key data source
  - ▶ yvar: county level population density from ICPSR & IPUMS
  - ▶ xvar: hydro dam from EPA eGRID and Idaho National Lab (INL)
  - ▶ Control group: suitable but never-treated locations identified by DOE & INL
- ▶ Approach
  - ▶ Main results: TWFE using **suitable but never-treated locations** as control
  - ▶ Robustness: Produce synthetic control estimates



# Treat & Control Counties

N = 28 (Treated before 1950); N = 51 (Treated after 1950); N = 31 (Control)

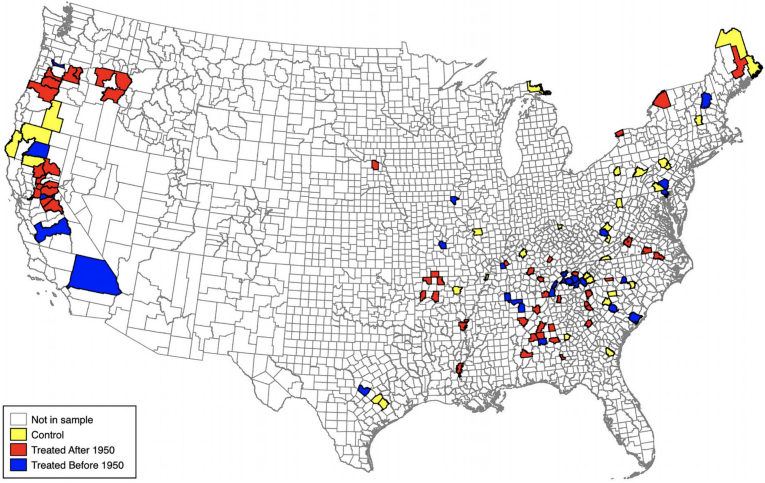


Fig. 3. Sample Counties: Treatment versus Control.

# Development in Hydro Power

## Federal Water Power Act of 1920

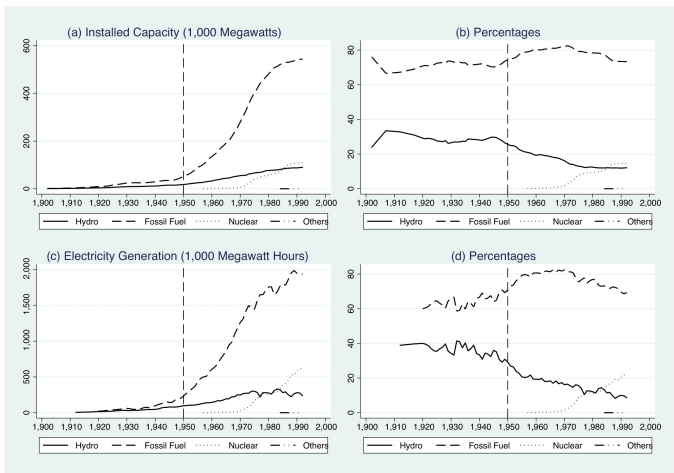
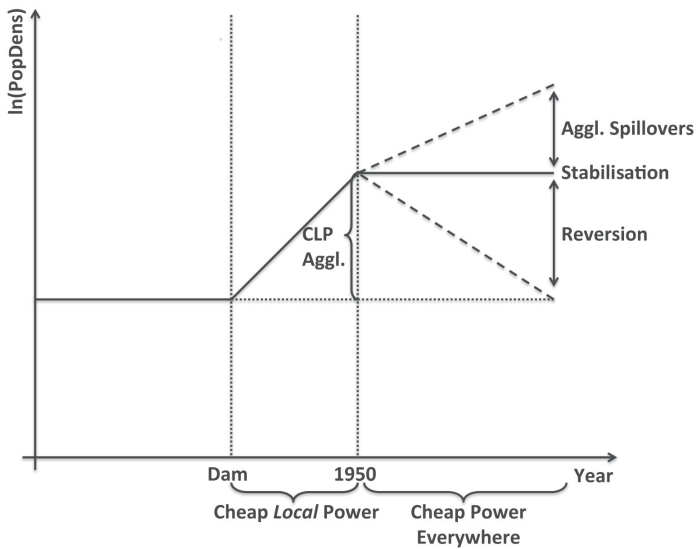


Fig. 1. Installed Capacity and Electricity Generation in the United States. (a) Installed Capacity (Hundred Megawatts). (b) Percentages. (c) Electricity Generation (Thousand-Megawatt Hours). (d) Percentages.

# Hypothesis: CLP only vs. CLP with spillover



# Historical Events for the CLP Hypothesis

## Before vs. After 1950s

Table B.1: Chronology of Industrial Electrification, and History of the U.S. Electric Power Industry

- 
- 1870: D.C. Electric Generator
  - \_\_73: Motors Driven by a Generator
  - \_\_81: Hydroelectric Dam Built Near Niagara Falls
  - \_\_82: Modern Electric Utility Industry Launched
  - \_\_83: Motors Used in Manufacturing
  - \_\_88: A.C. Motor Developed
  - \_\_91: A.C. Power Transmission for Industrial Use
  - \_\_92: A.C. Polyphase Induction Motor Marketed
  - \_\_95: A.C. Generation at Niagara Falls
  - 1900: A.C. Generator
  - \_\_01: Right-of-Way Act: Federal Govt. Entitled the Authority to Grant Permits for Hydro Projects
  - \_\_02: Reclamation Act: Federal Water Development Projects Initiated
  - \_\_06: General Dam Act: Private Owners Must Build and Operate Navigation Facilities W/O Compensation
  - \_\_07: State Regulation of Electric Utilities Started (Georgia, New York, and Wisconsin)
  - \_\_14-18: World War I
  - \_\_17: Capacity and Generation of Utilities Exceeded That of Industrial Establishments
  - \_\_20: Federal Water Power Act: Hydroelectric Licenses Revocable After Fifty Years
  - \_\_27: Supreme Court Ruling: Only Federal Govt. Can Regulate Interstate Wholesale Power Transactions
  - \_\_29: Wall Street Crash
  - \_\_33: Tennessee Valley Authority (TVA) Act: Local Development Fostered by Hydroelectricity
  - \_\_35: Federal Power Act: Interstate Wholesale Power Transactions Regulated
  - \_\_39-45: World War II
  - \_\_49: TVA authorized to construct thermal-electric power plants for commercial electricity sale
  - \_\_50: Construction of High-Voltage (230kV or more) Transmission Lines Began
  - \_\_54: Atomic Energy Act: Private Development of Commercial Nuclear Power Allowed
  - \_\_60: Current Level of Thermal Efficiency of Fossil-Steam Plants Reached
  - \_\_63: Clean Air Act (Amendments in 1970, 1977, and 1990): Pollution Regulation Initiated
  - \_\_64: Wilderness Act: Land Preservation Efforts Became Official

# Historical Shifts for the CLP Hypothesis

## Before vs. After 1950s

Table B.2: Domestic Economy – Percentage Distribution of Total Installed Electric Generating Capacity by Producer, 1889-1961

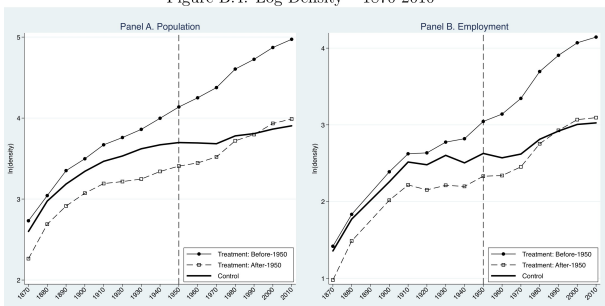
Year	Total Capacity	Industrial Establishments	Electric Utilities
1889	100.0	55.6	44.4
1899	100.0	53.4	46.6
1902	100.0	59.6	40.6
1907	100.0	60.2	39.8
1912	100.0	53.0	47.0
1917	100.0	42.0	58.0
1920	100.0	34.6	65.4
1925	100.0	28.6	71.4
1929	100.0	22.9	77.1
1935	100.0	19.6	80.4
1939	100.0	21.4	78.6
1947	100.0	19.7	80.3
1954	100.0	13.7	86.3
1958	100.0	11.0	89.0
1961	100.0	9.0	91.0

Source: DuBoff (1979, p.39).

# Other Historical Factors for the CLP Hypothesis

## Before vs. After 1950s

Figure B.4: Log Density – 1870-2010



- ▶ Siting is not random
- ▶ Choosing "almost-make-it" locations as control takes care the causality problem
- ▶ What about heterogeneous effect? Thought exercise:
  - ▶ What makes a location suitable before 1950s?
  - ▶ What makes a location suitable after 1950s?
  - ▶ What may be the difference between them?

# Empirical Strategy

## 1. Baseline: TWFE Event Study

For county  $c$  in decade  $t$ , estimate

$$Y_{ct} = \sum_y \beta_y D_{ct}^y + \alpha_c + \gamma_{rt} + \mathbf{Z}_c \phi_t + \mathbf{X}_{ct} \lambda + \varepsilon_{ct}, \text{ with event time } y \quad (1)$$

- ▶  $y$ : log population density
- ▶  $D^y$ : event time dummies
  - ▶ Event year: `evtime = year - year_treat`, with `year_treat = year of completion`
  - ▶ Variable `evtime`  $\in [-100, 80]$
  - ▶ Create dummies  $D^y$  based on `evtime` for -100, -90, -80,  $\dots$  50, 60, 70, 80 year
  - ▶ Default normalization: `evtime = -10`, a decade before
- ▶ Key coefficients of interest:  $\beta_y$
- ▶ Controls
  - ▶ County FE  $\alpha_c$ , census region (4)-by-year FE  $\gamma_{rt}$
  - ▶  $\mathbf{Z}_c \phi_t$ : cubic of latitude, cubic of longitude, rainfall, average seasonal temperature, miles of railroad tracks, distance to closest waterway, distance to closest MSA in 1030, access to highway in 1944)  $\times$  year FE
  - ▶  $\mathbf{X}_{ct}$ : cubic of steam-electric power plants capacities

# Main TWFE Results

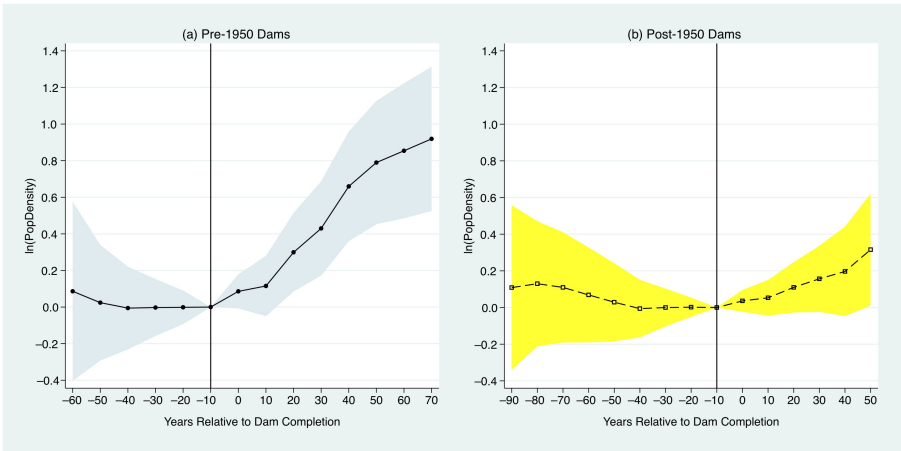


Fig. 4. Impact of Hydro Dams on Population Density: Short- and Long-Run Estimates. (a) Pre-1950 Dams. (b) Post-1950 Dams.

# Additional Results

## Heterogeneity

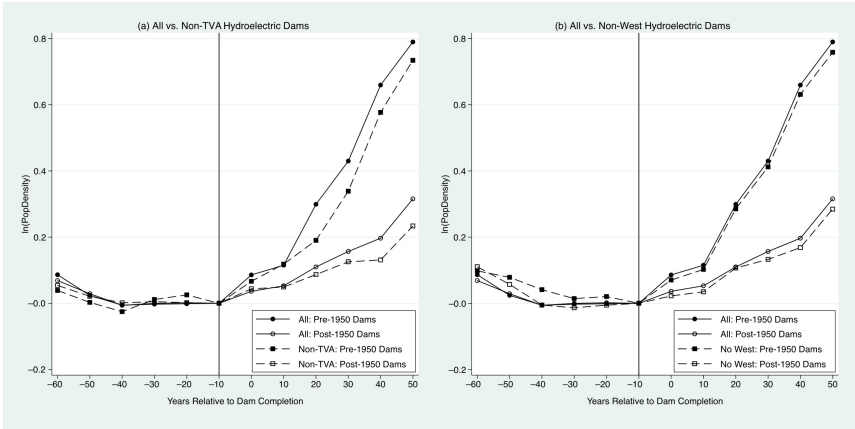


Fig. 6. *Impact of Hydro Dams on Population Density—Excluding TVA or West Dams. (a) All versus Non-TVA Hydroelectric Dams. (b) All versus Non-West Hydroelectric Dams.*

# Additional Results

## Other outcomes & sectoral effect

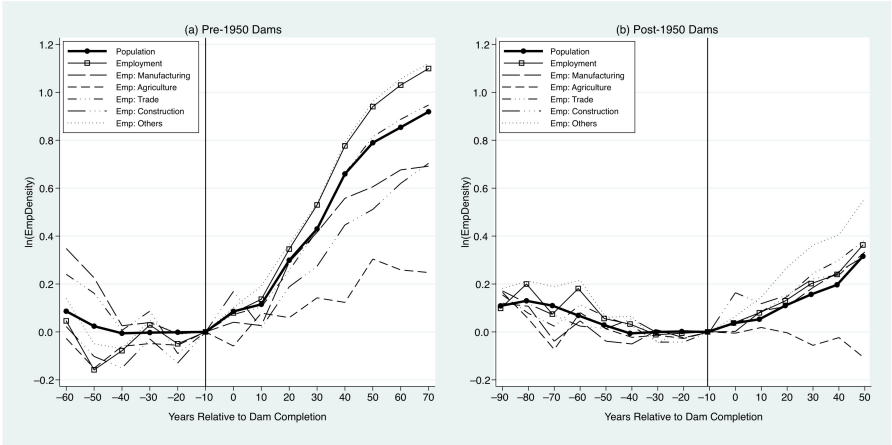
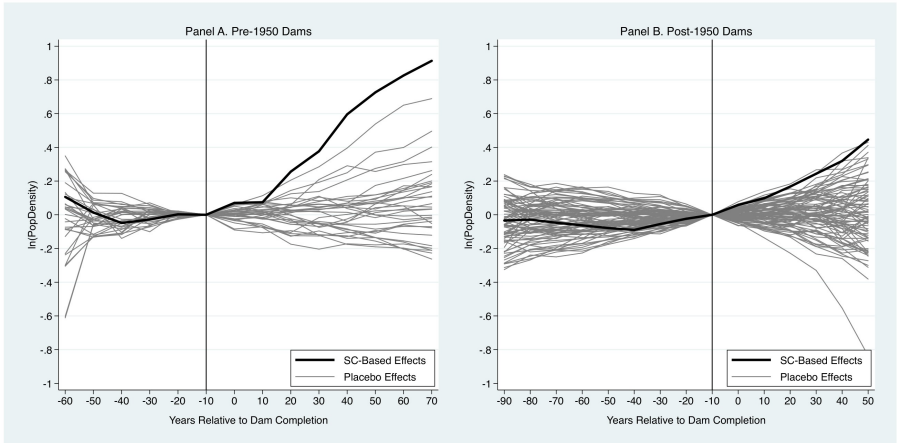


Fig. 7. Impact of Hydro Dams on Employment Density. (a) Pre-1950 Dams. (b) Post-1950 Dams.

# Additional Results

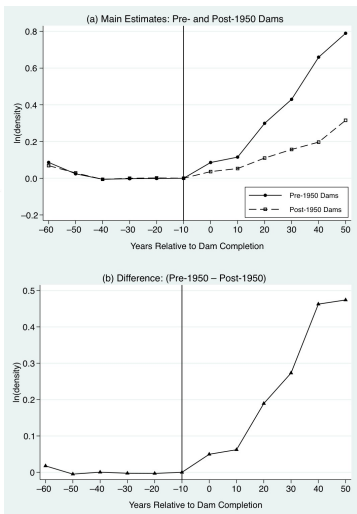
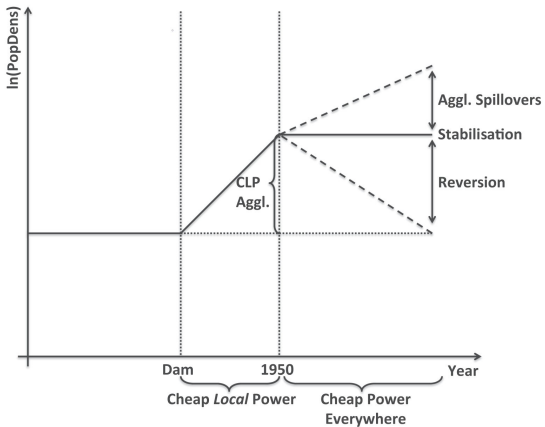
## Placebo

Figure C.4: Impact of Hydro Dams on Population Density – Placebo Tests



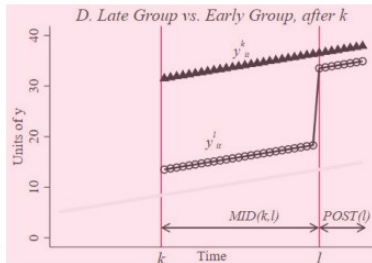
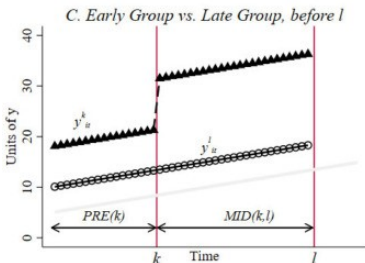
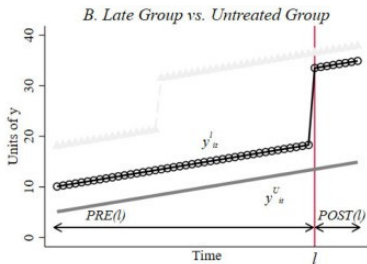
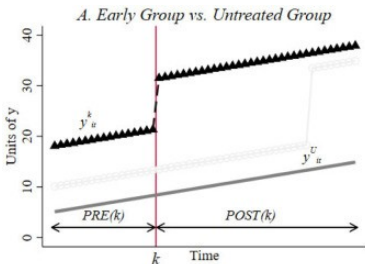
Notes: This Figure plots estimates of placebo tests with pre- and post-1950 dams. Each panel graphs estimated coefficients  $\beta$ 's of event-time dummies from equation (1) in the text for actual and artificially assigned treatments. The vertical solid line at one decade before dam completion facilitates the comparison of the dynamics before and after the treatment. It also points out that the dummy for event

# Main Results and the Hypothesis



# Potential Issues with TWFE: Type D

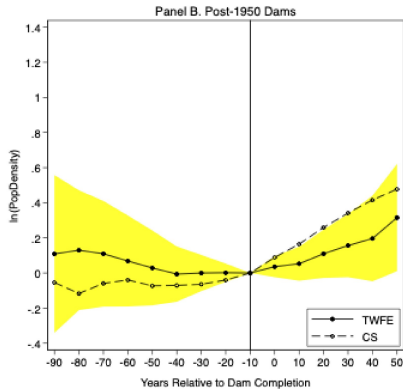
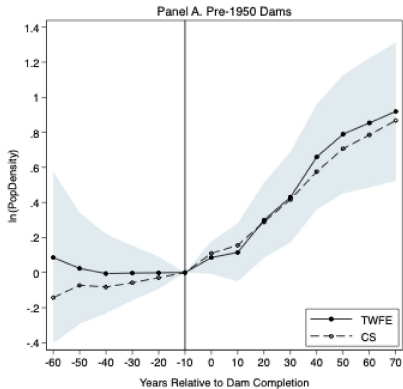
Solution from `csdid`: Only use never-treated (and not yet treated) as control





# Main Results: TWFE vs CSDID

## Sneakpeak of PS7: Re-run Fig 4 with CSDID



- ▶ You will be asked to reproduce Figure 4 in TWFE and CSDID
- ▶ For csdid: always check (i) effect for each cohort and (ii) weight
- ▶ What does the slight difference between TWFE & CSDID estimators tell you?

# Empirical Strategy

## 2. Synthetic Control Design

Consider a treated county  $c = 1$  in decade  $t$ . Suppose there are  $C$  number of potential comparable counties in the "donor pool"  $c \in [2, 3, \dots, C, C + 1]$ . Then the synthetic control estimator in post-shock period is:

$$Y_{1,t} - \sum_{c=2}^{C+1} w_c \cdot Y_{ct} \quad (2)$$

- ▶ First step: estimate the weight  $w_c$  with synth. The objective of the synthetic control estimator is to minimize the difference between county  $c = 1$ , vs the weighted average donor pool in some dimension  $X$ .
- ▶ Second step: Pool pairs of treated vs synthetic control counties and run an event study
- ▶ What usually go into  $X$ ?
  - ▶ Rule of thumb: Variables not affected by intervention
  - ▶ In practice  $X$  can include some pre-shock characteristics
  - ▶ It can even include outcome  $Y$  in pre-shock periods

# Empirical Strategy

## 2. Synthetic Control Design

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- ▶ First step: estimate the weight  $w_c$  with synth. The objective of the synthetic control estimator is to minimize the difference between county  $c = 1$ , vs the weighted average donor pool in some dimension  $X$ .
- ▶ Second step: Pool pairs of treated vs synthetic control counties and run an event study
- ▶ Choices of matching dimension  $X$  in this paper:
  - ▶ log (pre-dam population density)
  - ▶ Census region dummies (4)
  - ▶ It can even include outcome  $Y$  in pre-shock periods

# Main SC Results

## Example of 4 Dams

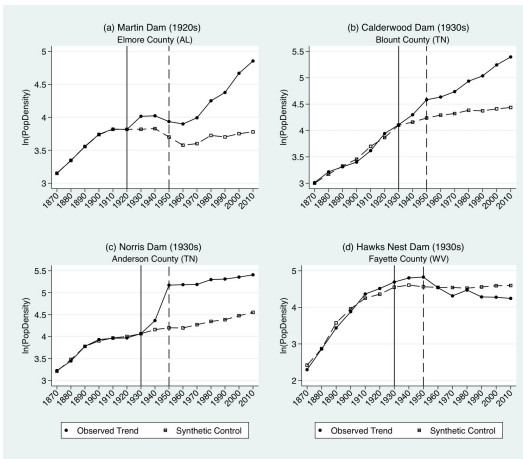
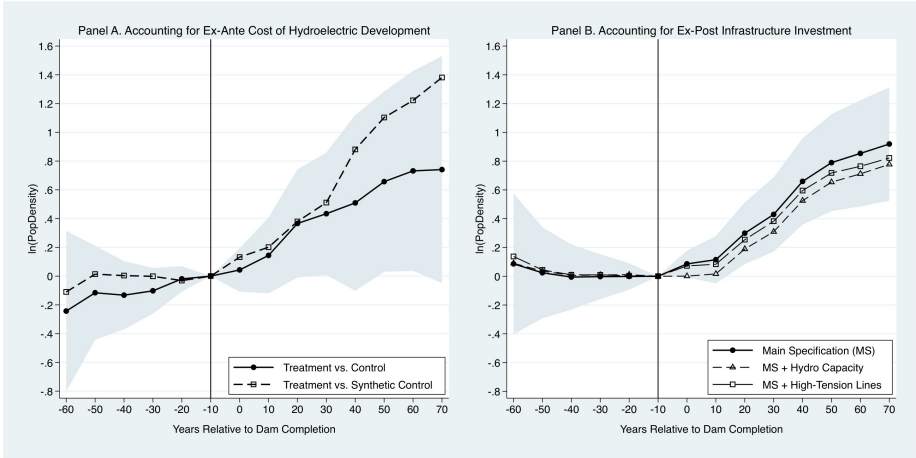


Fig. 9. Impact of Pre-1950 Hydro Dams on Population Density—Representative Synthetic Control Estimates. (a) Martin Dam (1920s). (b) Calderwood Dam (1930s). (c) Norris Dam (1930s). (d) Hawks Nest Dam (1930s).

# Main SC Results

Average SC effect (Left); Robustness with bad control (Right)

Figure C.5: Impact of Pre-1950 Hydro Dams on Population Density – Accounting for *Ex-ante* Cost of Hydropower Development and *Ex-post* Infrastructure Investment



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# Kahn & Mansur (2013) JPubE

"Do local energy price & regulations affect the geographic concentration of employment?"

## Research Question and Data:

- ▶ RQ: How does energy price variation affect employment of different manufacturing industries?
- ▶ Hypothesis:
  - ▶ Energy-intensive industries tend to develop in low(er) electricity price locations
  - ▶ Labor-intensive industries tend to grow in locations that are not pro-union
  - ▶ Pollution-intensive industries tend to grow locations with weaker Clean Air Act regulations
- ▶ Key data: US County Business Patterns (PUMS versions)
  - ▶ 1998 - 2009
  - ▶ 21 manufacturing industries
  - ▶ County level

# Empirical Strategy

For county  $i$ , county pair  $j$ , industry  $k$ , located under electricity utility company  $u$  and in state  $s$ , in year  $t$ , estimate

$$\begin{aligned} emp_{ijk,u,t} = & \beta_1 P_{ut}^{elec} + \beta_2 P_{ut}^{elec} ElecIndex_{kt} + \beta_3 RighttoWorkLaw_s LabCapRatio_{kt} \\ & + \beta_4 NonAttain_{it} + \beta_5 NonAttain_{it} PollIndex_k + \beta_6 NoMonitor_i + \beta_7 NoMonitor_i PollIndex_k \\ & + f(PollutionConcentration_{it}) + \delta Z_i + \alpha_j + \gamma_{kt} + \pi_{st} + \varepsilon_{ijk,u,t} \end{aligned} \quad (1)$$

$$\begin{aligned} emp_{ijk,u,t} = & \beta_1 P_{ut}^{elec} + \beta_2 P_{ut}^{elec} ElecIndex_{kt} + \beta_3 RighttoWorkLaw_s LabCapRatio_{kt} \\ & + \beta_4 NonAttain_{it} + \beta_5 NonAttain_{it} PollIndex_k + \beta_6 NoMonitor_i + \beta_7 NoMonitor_i PollIndex_k \\ & + f(PollutionConcentration_{it}) + \alpha_i + \gamma_{kt} + \pi_{st} + \varepsilon_{ijk,u,t} \end{aligned} \quad (2)$$

- ▶ Key FE in Eq(1): county pair  $j$  that includes 2 adjacent metropolitan counties
- ▶ Electricity index and pollution index from NBER  
BEA also has industry-specific energy cost share
- ▶ Key parameters of interest: Coefficients for those interaction terms
- ▶ Discuss: The purpose and the construction of these interaction terms
- ▶ Difference between Eq(1) and Eq(2)
  - ▶ Samples are different in two ways
  - ▶ Identification strategy is different

# Variation in Electricity Price across Locations

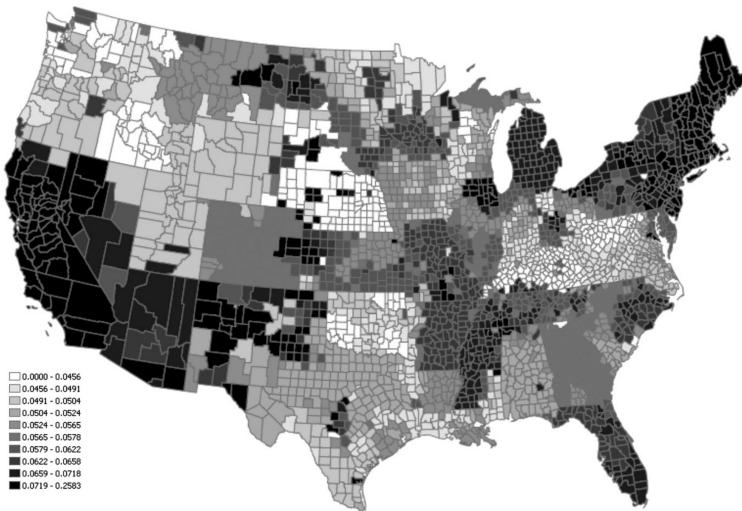


Fig. 1. Industrial electricity prices in 1998 (\$/kWh).

# Variation in "Exposure to Shock" across Industries

**Table 2**  
Industry details.

Industry	NAICS	Electricity	Normalized electricity		2002 Ozone emissions
		Index	Index	Labor-to-capital ratio	Rate
Primary metal manufacturing	331	0.816	1.000	0.007	2.845
Paper manufacturing	322	0.706	0.856	0.006	5.007
Textile mills	313	0.503	0.591	0.014	1.222
Nonmetallic mineral product manufacturing	327	0.454	0.527	0.013	7.046
Chemical manufacturing	325	0.402	0.459	0.004	1.897
Plastics and rubber products manufacturing	326	0.330	0.364	0.016	0.974
Wood product manufacturing	321	0.253	0.265	0.028	3.294
Petroleum and coal products manufacturing	324	0.245	0.254	0.002	9.715
Fabricated metal product manufacturing	332	0.185	0.175	0.020	0.426
Printing and related support activities	323	0.169	0.154	0.023	0.632
Textile product mills	314	0.165	0.149	0.035	0.345
Food manufacturing	311	0.149	0.128	0.013	0.749
Electrical equipment, appliance, and component manufacturing	335	0.137	0.112	0.017	0.336
Furniture and related product manufacturing	337	0.123	0.094	0.043	1.376
Leather and allied product manufacturing	316	0.110	0.077	0.035	0.547
Machinery manufacturing	333	0.103	0.068	0.014	0.156
Apparel manufacturing	315	0.102	0.067	0.047	0.028
Miscellaneous manufacturing	339	0.096	0.059	0.023	0.204
Beverage and tobacco product manufacturing	312	0.092	0.053	0.004	0.422
Transportation equipment manufacturing	336	0.086	0.045	0.011	0.401
Computer and electronic product manufacturing	334	0.051	0.000	0.007	0.038
Correlation with electricity index				-0.395	0.485
Units		kWh/shipsments		Work hours/capital	Tons/\$MM value added

Notes: Industries are defined by three-digit NAICS codes. Data thanks to Wayne Gray.



# Heterogeneity by Industry

**Table 4**  
Employment regressions by industry.

NAICS	Employees in 1998 (1000s)	Industry growth	BEA elect. cost share	Manufacturing industries	In N		Employees	
					Coef.	S.E.	Coef.	S.E.
311	1464	−.004%	1.17%	Food	0.03	(0.24)	239	(311)
312	173	−10%	0.79%	Beverage & tobacco product	0.02	(0.41)	−890	(396)**
313	385	−51%	2.40%	Textile mills	−0.31	(0.58)	−970	(344)***
314	217	−28%	0.77%	Textile product mills	0.17	(0.16)	−905	(312)***
315	671	−68%	0.54%	Apparel	0.25	(0.32)	227	(434)
316	79	−53%	0.66%	Leather & allied product	−0.10	(0.27)	−1026	(380)***
321	580	−1%	1.35%	Wood product	−0.59	(0.23)**	−1008	(329)***
322	568	−22%	3.34%	Paper	−0.47	(0.22)**	−728	(303)**
323	845	−24%	0.99%	Printing & related activities	0.27	(0.11)**	−60	(119)
324	111	−7%	0.78%	Petroleum & coal products	−0.59	(0.25)**	−1007	(371)***
325	901	−11%	3.49%	Chemical	0.08	(0.19)	143	(317)
326	1030	−13%	1.82%	Plastics & rubber products	−0.24	(0.15)	−240	(194)
327	508	−5%	2.20%	Nonmetallic mineral product	−0.33	(0.17)**	−723	(287)**
331	615	−27%	3.40%	Primary metal	−1.17	(0.26)**	−1053	(331)***
332	1816	−14%	1.42%	Fabricated metal product	−0.18	(0.14)	979	(555)*
333	1444	−22%	0.47%	Machinery	−0.31	(0.18)*	−211	(260)
334	1681	−37%	0.27%	Computer & electronic product	0.67	(0.26)**	2185	(910)**
335	602	−30%	0.66%	Electrical equipment, appliance	0.11	(0.20)	−574	(256)**
336	1911	−15%	0.21%	Transportation equipment	−0.80	(0.28)***	−243	(578)
337	604	−10%	0.70%	Furniture & related product	−0.11	(0.14)	−584	(155)***
339	737	−7%	0.49%	Miscellaneous	0.71	(0.12)***	574	(194)***
				<i>Other industries</i>				
238	8926	26%	1.28%	Specialty trade contractors	0.10	(0.06)*	−825	(576)
441	1757	11%	1.28%	Motor vehicle & parts dealers	−0.06	(0.06)	−797	(315)**
445	2944	−1%	1.28%	Food & beverage stores	0.03	(0.12)	−786	(412)*
452	4263	−34%	1.28%	General merchandise stores	−0.07	(0.06)	−549	(288)*
522	2688	22%	0.10%	Credit intermediation & related	−0.15	(0.08)*	−277	(350)
524	2312	3%	0.11%	Insurance carriers & related	−0.22	(0.12)*	−340	(389)
541	6052	33%	0.19%	Professional, scientific & techn.	−0.18	(0.09)*	−4099	(1717)**
551	2704	8%	0.63%	Management of companies	−0.15	(0.13)	−1514	(540)***
561	8366	27%	0.28%	Administrative & support	−0.07	(0.11)	−3151	(1245)**
611	2324	28%	2.18%	Educational services	0.02	(0.11)	−81	(605)
621	4482	27%	0.35%	Ambulatory health care	0.07	(0.05)	−14	(528)
622	5011	7%	1.13%	Hospitals	−0.13	(0.11)	463	(477)
623	2511	19%	1.38%	Nursing & residential care	0.14	(0.05)***	107	(191)
722	7758	22%	1.96%	Food services & drinking places	0.00	(0.04)	−2854	(1218)**
813	2488	12%	0.20%	Religious, grantmaking, civic	−0.04	(0.04)	14	(187)

Notes: For manufacturing industries, we modify Eq. (1) so that each industry has a separate price coefficient. For non-manufacturing industries, we estimate Eq. (1) separately for each industry. Industry growth is from 1998 to 2006. See Table 3's notes for further details.

# Interpret Main Results in Table 3

**Table 7**

Summary table of main results.

Regulation or price	Least intensive	Average intensity	Most intensive
Electricity	(e.g. Computers)		(e.g. Primary metals)
Electricity priceElasticity	0.172 (0.270)	-0.227* (0.134)	-1.652*** (0.621)
Labor	(e.g. Petroleum/coal)		(e.g. Apparel)
Right-to-workPercentage	2.1%*** (0.6%)	21.9%*** (6.6%)	67.0%*** (20.3%)
Pollution	(e.g. Apparel)		(e.g. Petroleum/coal)
Ozone nonattainment percentage	13.1%* (6.9%)	4.3% (4.7%)	-64.6%*** (24.5%)
Ozone no monitorPercentage	-15.0%** (6.6%)	-5.8% (5.9%)	66.3%*** (14.1%)

Notes: We report elasticities and percentages based on Table 3, Column (1) estimates and Table 1's average number of workers per observation. Standard errors are reported in parentheses using the delta method. Average intensity is a worker-weighted average of the county-industry-year observations in our sample and equals 0.28 and 0.11 for the normalized electricity and ozone indices, respectively. See Table 3's notes for further details.

# Outline

- ▶ Topics in Energy Economics on Regional Growth and Local Labor Market Effect ✓
- ▶ Example 1-2: Previously Covered: Fabra et al. (2024) + Allcott & Keniston (2018) ✓
- ▶ Example 3: Severnini (2022) EJ ✓
- ▶ Example 4: Kahn & Mansur (2013) JPubE ✓
- ▶ Example 5: Muehlenbachs, Spiller, & Timmins (2015) AER
- ▶ Example 6: Yip (2018) JEEM
- ▶ Example 7: Brehm et al. (2025) Working Paper

# Muehlenbachs, Spiller, & Timmins (2015) AER

## "The Housing Market Impacts of Shale Gas Development"

### Research Question:

- ▶ What's the impact of local shale gas development (fracking) on local property values in PA?

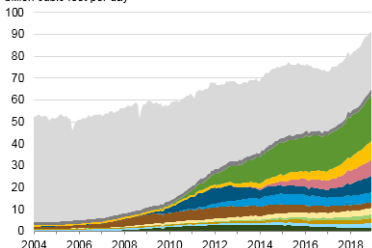
### Background info:

- ▶ We know natural gas is less pollution-intensive and more cost-competitive than coal when it is burned for electricity generation, aka, it is a "green(er)" fossil fuel in power sector
- ▶ But the extraction sector is different...
- ▶ Potential local gains:
  - ▶ local agglomeration/multiplier effect from these big projects (employment, public finance, in-flow migration, in-flow businesses)
  - ▶ lease & royalty payments from drilling companies to hh with mineral rights
- ▶ Potential local loss:
  - ▶ Water pollution, air pollution, noise
  - ▶ A bit unsightly
- ▶ **Focus of this paper:** marginal benefits and costs reflected in property value

# The Recent US Oil & Gas Boom from Shale Gas

Monthly U.S. dry natural gas production (2004-2018)

billion cubic feet per day

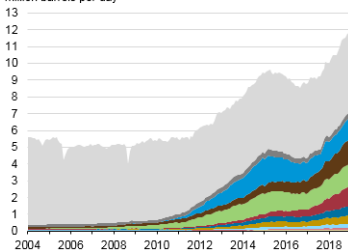


- rest of U.S.
- other U.S. shale gas
- Marcellus (Pa., W.Va., Ohio, N.Y.)
- Permian (Texas, N.M.)
- Utica (Ohio, Pa., W.Va.)
- Haynesville (La., Texas)
- Eagle Ford (Texas)
- Barnett (Texas)
- Woodford (Okla.)
- Bakken (N.D., Mont.)
- Niobrara-Codell (Colo., Wyo.)
- Mississippian (Okla.)
- Fayetteville (Ark.)



Monthly U.S. crude oil production (2004-2018)

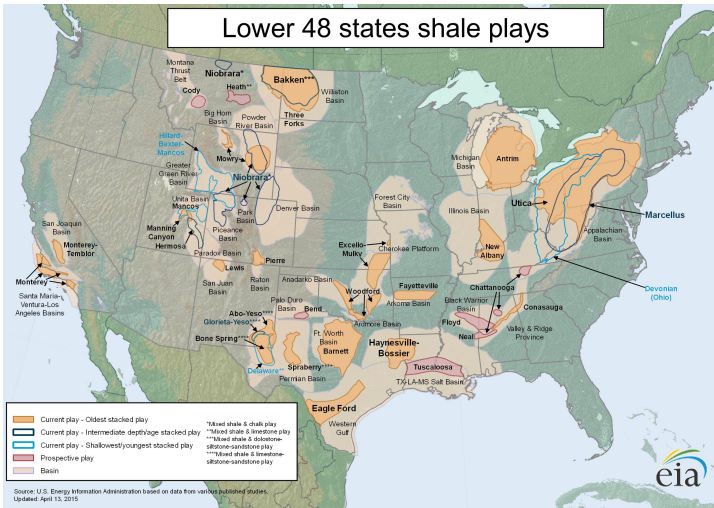
million barrels per day



- rest of U.S.
- other U.S. tight oil
- Eagle Ford (Texas)
- Spraberry (Texas Permian)
- Bakken (N.D., Mont.)
- Wolfcamp (Texas and N.M. Permian)
- Bonespring (Texas and N.M. Permian)
- Niobrara-Codell (Colo. and Wyo.)
- Mississippian (Okla.)
- Austin Chalk (La., Texas)
- Woodford (Okla.)



# The Recent US Oil & Gas Boom from Shale Gas

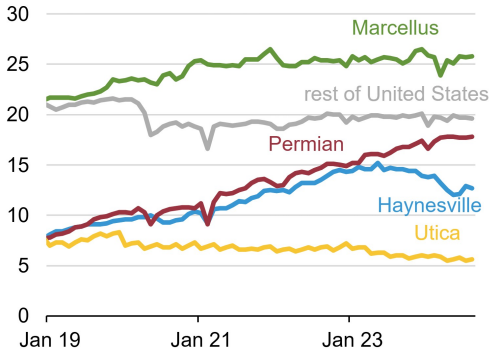


# The Recent US Oil & Gas Boom from Shale Gas

Shale gas in PA (focus of this paper)

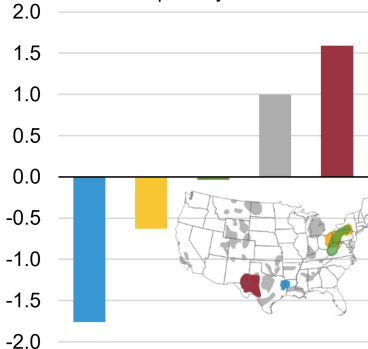
**Monthly U.S. shale natural gas production (Jan 2019–Sep 2024)**

billion cubic feet per day



**Change in production (Jan–Sep 2024 compared with Jan–Sep 2023)**

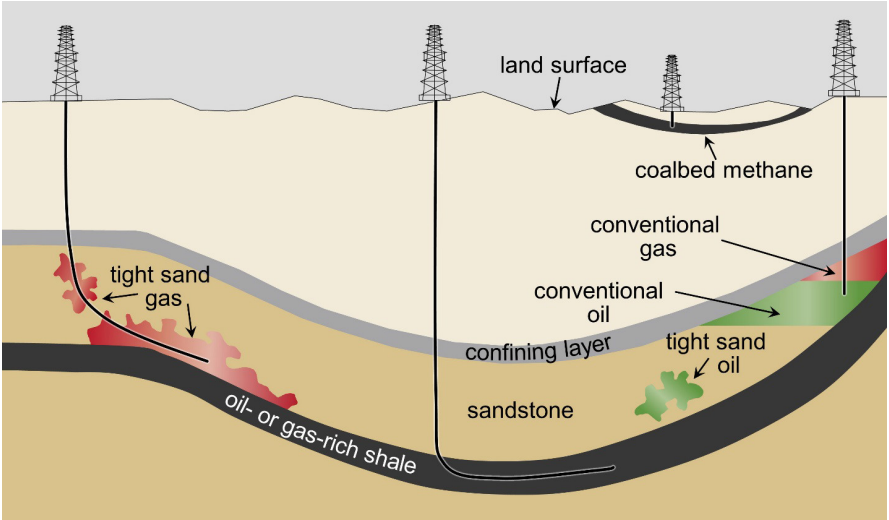
billion cubic feet per day





# The Contributing Technology for Shale Gas Boom

## Fracking vs. conventional technology





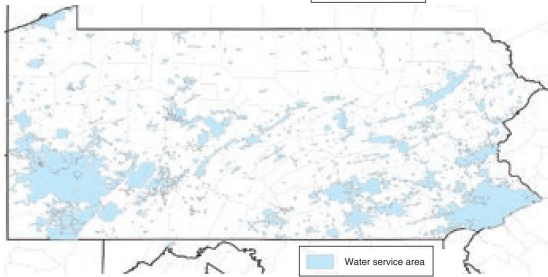
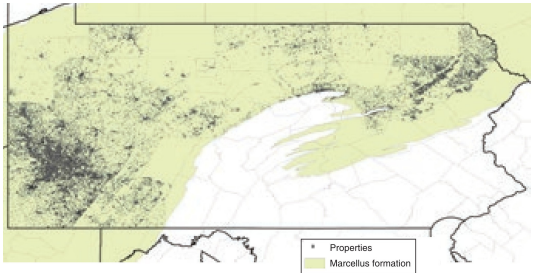
# Also Potential Disutility from Being Unsightly







# Key Variation: Locations with PWSA





# Empirical Strategy

For household  $i$  in county  $c$  and time (year quarter)  $t$ , estimate

$$\ln P_{it} = \alpha_0 + \alpha_1 \mathbf{1}(Padsin20km)_{it} + \alpha_2 GW_i \mathbf{1}(Padsin20km)_{it} + \alpha_3 \mathbf{1}(Padsin2km)_{it} + \alpha_4 GW_i \mathbf{1}(Padsin2km)_{it} + \mu_i + \nu_{ct} + t + \varepsilon_{it} \quad (4)$$

- ▶  $GW_i$ : A dummy if a household depends on ground water (GW)
- ▶ Key parameters of interest:  $\alpha_4$ 
  - ▶ Group A (GW + Vicinity)  $\Delta \ln P_A = \alpha_1 + \alpha_2 + \alpha_3 + \alpha_4$
  - ▶ Group B (GW + Far)  $\Delta \ln P_A = \alpha_1 + \alpha_2$
  - ▶ Group C (PWCD + Vicinity)  $\Delta \ln P_A = \alpha_1 + \alpha_3$
  - ▶ Group D (PWCD + Far)  $\Delta \ln P_A = \alpha_1$
  - ▶ Ergo  $\Rightarrow (\Delta \ln P_A - \Delta \ln P_B) - (\Delta \ln P_C - \Delta \ln P_D) = \alpha_4$
- ▶  $\alpha_4$  will gives you the overall DDD effect of both +/- effect from fracking in the backyard
- ▶  $\alpha_3$  will isolate the positive effect excluding the pollution impact

# Main Results

TABLE 2—LOG SALE PRICE ON WELL PADS

	$K \leq 1$ km		$K \leq 1.5$ km		$K \leq 2$ km	
	Full (1)	Boundary (2)	Full (3)	Boundary (4)	Full (5)	Boundary (6)
<i>Panel A. County-year fixed effects</i>						
Pads in $K$ km $\alpha_3 \rightarrow$	0.028 (0.025)	0.026 (0.035)	0.029** (0.014)	0.034* (0.02)	0.016** (6.9e-03)	0.018* (0.01)
(Pads in $K$ km) $\times$ GW $\alpha_4 \rightarrow$	-0.062 (0.046)	-0.165** (0.072)	-0.042* (0.025)	-0.099*** (0.036)	-0.023 (0.02)	-0.013 (0.052)
Pads in 20 km	-7.8e-04*** (3.0e-04)	-8.1e-04 (5.3e-04)	-8.3e-04*** (3.0e-04)	-9.3e-04* (5.5e-04)	-8.4e-04*** (3.0e-04)	-9.4e-04* (5.6e-04)
(Pads in 20 km) $\times$ GW	6.6e-04 (4.7e-04)	2.0e-03*** (7.0e-04)	7.0e-04 (4.9e-04)	2.0e-03*** (6.8e-04)	7.1e-04 (5.2e-04)	1.7e-03** (6.8e-04)
Property effects	Yes	Yes	Yes	Yes	Yes	Yes
County-year effects	Yes	Yes	Yes	Yes	Yes	Yes
Quarter effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	229,946	66,327	229,946	66,327	229,946	66,327
$p$ -value ( $\alpha_3 + \alpha_4 = 0$ )	0.414	0.051	0.544	0.090	0.740	0.919
Avg. pads in $K$ km	0.003	0.006	0.009	0.015	0.018	0.031
Avg. pads in 20 km	4.725	5.108	4.725	5.108	4.725	5.108

- Back-of-envelop of -9.9 to -16.5%: About \$30,167 loss on average (in 2012 USD)

# Subsample of Areas C & D: Adjacent Effect

TABLE 3—ADJACENCY EFFECTS

	$K = 1$ km (1)	$K = 1.5$ km (2)	$K = 2$ km (3)
	ln(price)	ln(price)	ln(price)
<i>Panel A. log sale price on well pads in view</i>			
Visible well pads in $K$ km	1.1e-03 (0.072)	-0.019 (0.058)	0.019 (0.035)
Not-visible well pads in $K$ km	0.03 (0.028)	0.036*** (0.013)	0.015** (6.5e-03)
Pads in 20 km	-6.0e-04* (3.3e-04)	-6.4e-04* (3.3e-04)	-6.5e-04* (3.3e-04)
<i>Panel B. log sale price on productive wells</i>			
Unproductive pads in $K$ km	-0.052 (0.077)	-0.043 (0.035)	-0.054* (0.03)
Producing pads in $K$ km	0.044** (0.02)	0.038*** (0.013)	0.02*** (5.8e-03)
Pads in 20 km	-6.0e-04* (3.3e-04)	-6.4e-04* (3.3e-04)	-6.3e-04* (3.3e-04)
<i>Panel C. log sale price on timing of wellbores</i>			
Old bores (drilled > 365 days) in $K$ km	0.021 (0.018)	0.023** (9.8e-03)	0.011** (4.4e-03)
New bores (drilled ≤ 365 days) in $K$ km	-4.4e-03 (0.029)	-9.7e-03 (0.013)	-3.3e-04 (8.0e-03)
Old undrilled permits (> 365 days) in $K$ km	0.055*** (0.025)	0.022 (0.014)	0.011 (0.012)
New undrilled permits (≤ 365 days) in $K$ km	0.04* (0.023)	7.2e-03 (0.014)	7.2e-03 (7.9e-03)
Pads in 20 km	-6.0e-04* (3.3e-04)	-6.2e-04* (3.3e-04)	-6.3e-04* (3.3e-04)
Property effects	Yes	Yes	Yes
County-year effects	Yes	Yes	Yes
Quarter effects	Yes	Yes	Yes
Observations	212,207	212,207	212,207

# (Why) Can We Call $\hat{\alpha}$ s MWTP?

## Hedonic price gradient

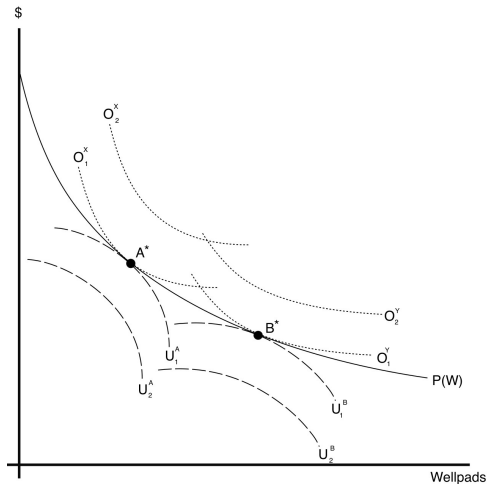


Figure B.1: Formation of the Hedonic Price Function

# Assumptions Needed

(i) Constant MWTP + (ii) homogeneous preference

E.g., if hedonic function/schedule moved, then...

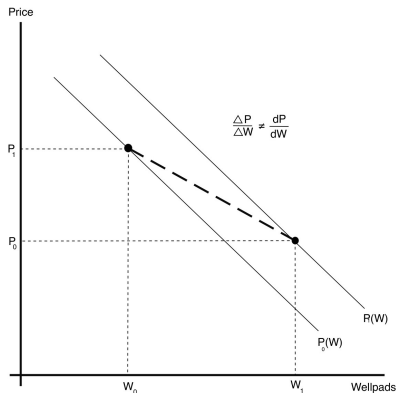
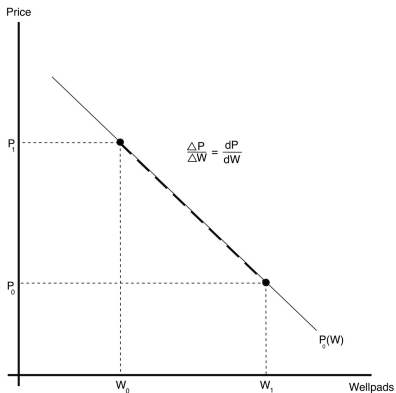


Figure B.4: Time-Varying  $P(W)$

# Outline

- ▶ Topics in Energy Economics on Regional Growth and Local Labor Market Effect ✓
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- ▶ Example 5: Muehlenbachs, Spiller, & Timmins (2015) AER ✓
- ▶ Example 6: Yip (2018) JEEM
- ▶ Example 7: Brehm et al. (2025) Working Paper

# Yip (2018) JEEM

## "On the labor market consequences of environmental tax"

### Research Question:

- ▶ What's the local labor market effect of carbon tax in British Columbia?
- ▶ Affected parties:
  - ▶ Industries that use fuel
  - ▶ Residents that use fuel
  - ▶ Starts at 10 CAD per ton in 2008 to 30 CAD per ton in 2012
- ▶ Data: PUMS version of Canada LFS (monthly hh survey)
- ▶ Design: Classic 2-by-2 Diff-in-Diff
  - ▶ Treated (BC) vs Control (other provinces)
  - ▶ Pre vs Post (later than July 2008)

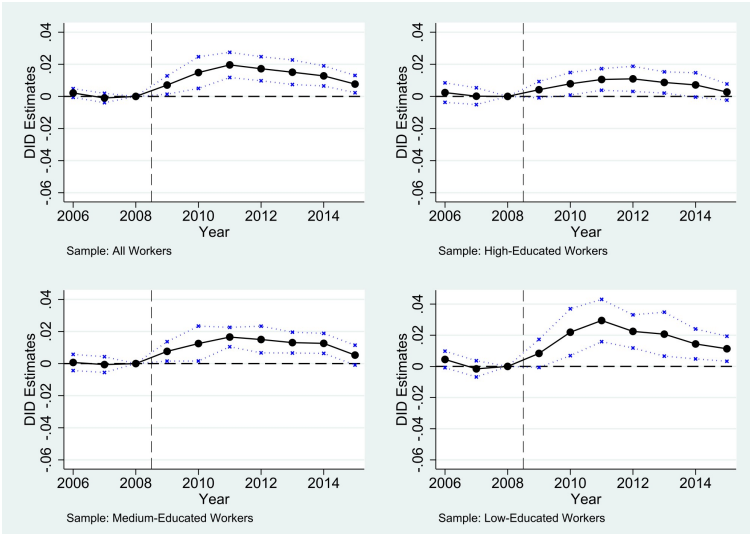
# Main Results

**Table 2**

The effects on the number of working hours, the unemployment rate, and the LFP rate.

	Difference-in-Differences Analysis			
	(1)	(2)	(3)	(4)
<b>A. Dependent Variable: ln(Weekly Working Hours)</b>				
<i>BC</i> × <i>Post</i>	-0.007 (0.005)	-0.009* (0.005)		
<i>BC</i> × <i>Tax</i>			-0.018 (0.025)	-0.024 (0.022)
<b>B. Dependent Variable: Unemployed</b>				
<i>BC</i> × <i>Post</i>	0.012*** (0.003)	0.013*** (0.003)		
<i>BC</i> × <i>Tax</i>			0.043*** (0.008)	0.046*** (0.010)
<b>C. Dependent Variable: LFP</b>				
<i>BC</i> × <i>Post</i>	-0.002 (0.005)	-0.003 (0.005)		
<i>BC</i> × <i>Tax</i>			-0.026 (0.023)	-0.021 (0.020)

# Main Results



# Outline

- ▶ Topics in Energy Economics on Regional Growth and Local Labor Market Effect ✓
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- ▶ Example 6: Yip (2018) JEEM ✓
- ▶ Example 7: Brehm et al. (2025) Working Paper

# Brehm, Brehm, Cassidy, & Cassidy (2025) WP

## "Resource extraction, revenue sharing, & growth"

### Research Question:

- ▶ RQ1: What is the impact of the local oil boom on local growth?
- ▶ RQ2: What is the impact of revenue-sharing on local growth?
- ▶ Why is this study special?
- ▶ Setting: Indonesia 1975 - 2015
- ▶ Shock 1: Oil price shock
  - ▶ shocks resource-rich and resource-poor districts differently
- ▶ Shock 2: Fiscal shock of 1999

A decentralization reform that creates revenue-sharing across districts in the same province

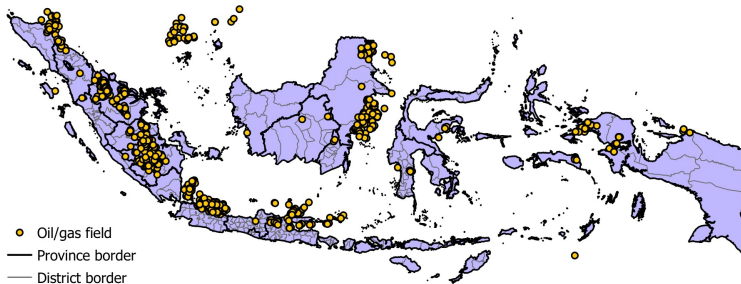
- ▶ shocks fiscal-endowment-rich and poor districts differently



# Cross variation:

## Onshore resource endowment

(a) Oil and Gas Fields of Indonesia





# Construction of Fiscal Endowment across District

This is actually the fiscal endowment (from oil & gas)

- ▶ For most provinces, they allocate oil or gas revenue of a district  $d$ :
- ▶ Oil: 15% oil to sub-national govt, 3% to the province, 6% to the district, 6% to other districts in the same province
- ▶ Gas: 30% oil to sub-national govt, 6% to the province, 12% to the district, 12% to other districts in the same province
- ▶ A slightly different formula for the 3 remaining provinces

$$F_{d,t}^{oil} = \frac{1}{Pop_{d,1980}} \left( 0.06 \cdot R_{d,t}^{oil} + \frac{0.06}{N_{p(d),t} - 1} \cdot \sum_{\substack{j \neq d \\ p(j)=p(d)}} R_{j,t}^{oil} + 0.03 \cdot S_{d,t} \cdot \sum_j R_{j,t}^{oil} \right),$$

$$F_{d,t}^{gas} = \frac{1}{Pop_{d,1980}} \left( 0.12 \cdot R_{d,t}^{gas} + \frac{0.12}{N_{p(d),t} - 1} \cdot \sum_{\substack{j \neq d \\ p(j)=p(d)}} R_{j,t}^{gas} + 0.06 \cdot S_{d,t} \cdot \sum_j R_{j,t}^{gas} \right).$$

$$F_d^{oil} = \frac{1}{14} \sum_{t=2001}^{2014} F_{d,t}^{oil}, \quad F_d^{gas} = \frac{1}{14} \sum_{t=2001}^{2014} F_{d,t}^{gas}.$$

# Empirical Strategy

**Regression 1.** For a manufacturing firm  $i$  (of industry  $j$ ) in district  $d$  (of region  $r$ ) and year  $t$ , estimate

$$\begin{aligned} \ln Y_{idt} = & \beta \mathbf{P}'_t \mathbf{E}_d \\ & + \delta (\mathbf{P}'_t \mathbf{F}_d) \times Post_t \cdot \mathbf{1}(\mathbf{E}_d = 0) \\ & + \gamma (\mathbf{P}'_t \mathbf{F}_d) \times Post_t \cdot \mathbf{1}(\mathbf{E}_d > 0) + \alpha_i + \phi_{jt} + \lambda_{rt} + \varepsilon_{it} \end{aligned} \quad (1)$$

- ▶  $Y$ : firm-level outcomes, e.g., firm output, worker-level outcome
- ▶  $\mathbf{P}'_t \mathbf{E}_d = P_t^{oil} E_d^{oil} + P_t^{gas} E_d^{gas}$
- ▶  $\mathbf{P}'_t \mathbf{F}_d = P_t^{oil} F_d^{oil} + P_t^{gas} F_d^{gas}$
- ▶  $Post = 1$  if  $year \geq 1999$

**Regression 2.** For a district  $d$  (of region  $r$ ) and year  $t$ , estimate

$$\begin{aligned} \ln Y_{dt} = & \beta \mathbf{P}'_t \mathbf{E}_d \\ & + \delta (\mathbf{P}'_t \mathbf{F}_d) \times Post_t \cdot \mathbf{1}(\mathbf{E}_d = 0) \\ & + \gamma (\mathbf{P}'_t \mathbf{F}_d) \times Post_t \cdot \mathbf{1}(\mathbf{E}_d > 0) + \alpha_d + \lambda_{rt} + \varepsilon_{it} \end{aligned} \quad (3)$$

- ▶  $Y$ : district-level outcome, e.g., non-oil GDP

# Results

## Manufacturing firm outcomes at district level

Table 1: Firm Outcomes: Static Model

	Log(Outcome)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Output	Value Added	Number of Workers	Output per Worker	Value Added per Worker	Wage
Onshore Endow. × Price	0.52*** (0.07)	0.18* (0.09)	0.01 (0.05)	0.51*** (0.05)	0.20*** (0.07)	0.23*** (0.05)
Fiscal Endow. × Price × ( $t \geq 1999$ ) × (Onshore = 0)	0.64 (4.12)	3.63 (4.92)	3.47 (2.59)	-2.82 (3.65)	0.19 (3.83)	-3.17** (1.50)
Fiscal Endow. × Price × ( $t \geq 1999$ ) × (Onshore > 0)	-0.62 (0.60)	0.21 (0.75)	0.65* (0.36)	-1.27** (0.50)	-0.55 (0.65)	-1.79*** (0.52)
<i>p</i> -value: No Interaction Effect	0.758	0.486	0.283	0.665	0.843	0.378
Observations	481,795	462,594	481,783	481,783	462,594	480,875
Plants	52,182	51,316	52,182	52,182	51,316	52,084
Districts	280	280	280	280	280	280

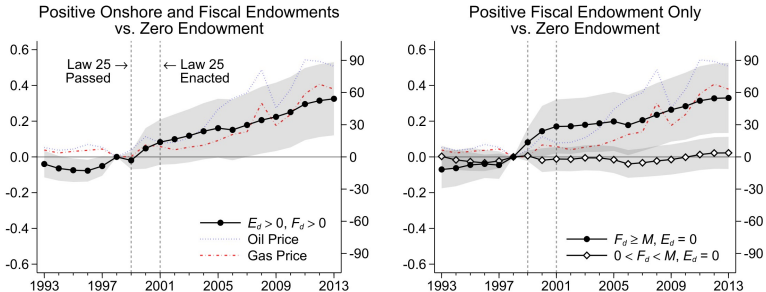
*Notes:* This table presents fixed-effects estimates of the coefficients in Equation (1) for  $K = 0$ . The *p*-values correspond to the test of  $H_0: \delta_0 = \gamma_0$ . Each endowment × price variable is measured in constant 2010 USD millions per capita based on 1980 population. Standard errors, reported in parentheses, are robust to heteroskedasticity and clustering at the level of 1975 district borders. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .



# Results

## M is cutoff between high- vs low-fiscal-endowment group

Figure 4: Difference-in-Differences: Log Non-Oil GDP



*Notes:* This figure plots estimates and 95-percent confidence intervals for  $\{\beta_s\}$  (left panel),  $\{\delta_s^h\}$  (right panel), and  $\{\delta_s^\ell\}$  (right panel) in Equation (4) (left axis). Vertical dashed lines indicate the years the decentralization law was passed and enacted. Oil and gas prices are expressed in deviations from their 1998 values, in constant 2010 USD per barrel of oil equivalent (right axis). Confidence intervals are robust to heteroskedasticity and clustering at the level of 1993 district borders.