

**ECON 8000/9000 Empirical Energy Econ**  
**Topic 06: Bartik IV and Shift Share Design**

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**February 4, 2026**

# Outline

- ▶ Introduction: Bartik/Shift-share IVs
- ▶ Example Krause (2026) JEEM

# Introduction: Where things started

## The literature on (i) local labor market effect and (ii) migration of a shock

Researchers like to evaluate how a shock  $x_{lt}$  in location  $l$  at time  $t$  affect local labor market outcomes  $y$

$$y_{lt} = \beta x_{lt} + \gamma \mathbf{K}_{lt} + \phi_l + \phi_t + \varepsilon_{lt} \quad (1)$$

- ▶  $y$ : typical outcomes include employment, wage, migration (in-, out-, net-), population, business establishments, payroll, transfer payment (welfare program)
- ▶  $x$ : shocks in location  $l$  at time  $t$ 
  - ▶ China shock (e.g., Autor et al. 2013 AER, Acemoglu et al. 2016 JOLE)
  - ▶ Automation in manufacturing (e.g., Autor & Dorn 2013 AER, Autor et al. 2019 AER-I)
  - ▶ Fracking boom (e.g., Feyrer et a. 2017 AER; Kearney & Wilson 2018 REStat; Wilson 2022 JHR)
  - ▶ Oil boom & bust (e.g., Allcott & Keniston 2018 RES)
  - ▶ Coal-mining phase-out (e.g., Hanson 2023 WP; Krause 2024 JEEM)
- ▶ Also include: controls  $\mathbf{K}_{lt}$  and FEs  $\phi_l, \phi_t$ , etc.

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  - ▶ Oil boom & bust (e.g., Allcott & Keniston 2018 RES)
  - ▶ Coal-mining phase-out (e.g., Hanson 2023 WP; Krause 2024 JEEM)
- ▶ Also include: controls  $\mathbf{K}_{lt}$  and FEs  $\phi_l, \phi_t$ , etc.
- ▶ Various versions of Eq (1):
  - ▶ (i) stacked 1st FD, (ii) long FD, (iii) event studies (ES), (iv) LP-DID
  - ▶ Usually people use FD instead of FE. FD can be evaluated in ES and LP-DID too
- ▶ Key endogeneity issues: treatment (shock  $x_{lt}$ ) may correlate with confounders in  $\varepsilon_{lt}$

# Study local labor market effects from a shock

## Original idea of Shift-share IV

Evaluate how a shock  $x_{lt}$  in location  $l$  at time  $t$  affect local labor market outcomes  $y$

$$y_{lt} = \beta x_{lt} + \gamma \mathbf{K}_{lt} + \phi_l + \phi_t + \varepsilon_{lt} \quad (1)$$

- ▶ Key endogeneity issues: treatment (shock  $x_{lt}$ ) may correlate with confounders in  $\varepsilon_{lt}$

Solution: consider an IV  $z_{lt}$

$$z_{lt} = \sum_j s_{j,t_0} \cdot g_{j,t} \quad (2)$$

share<sub>j</sub>      shift<sub>j,t</sub>

- ▶ This is known as shift-share IV or Bartik IV, popularized following Bartik (1991)
- ▶ **Share:**
  - ▶ Each location has many industries:  $j \in \{1, 2, \dots, J\}$
  - ▶ Each location  $l$  has its own industrial composition  $s_{j,l}$  initially at time  $t_0$
  - ▶ Ergo, each location will experience various "exposure to treatment" for a given national industry-specific shock
- ▶ **Shift:**
  - ▶ Each industry  $j$  will be affected by macroeconomic shock in various degree
- ▶ Traditionally, the exogenous variation relies on the "share" element in most studies

# Construction of a Shift-share IV

## Version 1: Original idea, an inner-product

$$z_{lt} = \sum_j \frac{S_{lj,t_0}}{\text{share}_{lj}} \cdot \frac{g_{j,t}}{\text{shift}_{jt}} \quad \text{or simply (suppress subscript), } z_{lt} = \sum_j \frac{S_{lj}}{\text{share}_{lj}} \cdot \frac{g_{jt}}{\text{shift}_{jt}} \quad (2)$$

Consider a toy example of 3 locations, 3 industries, and 3 years:

loc	year	$x_{lt}$	$share_{lj}$			$shift_{jt}$			$z_{lt}$
			$share_{mfr}$	$share_{serv}$	$share_{agr}$	$shift_{mfr}$	$shift_{serv}$	$shift_{agr}$	
A	2021	0.058	0.6	0.2	0.2	0.02	0.15	0.02	0.046
A	2022	0.015	0.6	0.2	0.2	-0.05	0.20	-0.01	0.008
A	2023	-0.018	0.6	0.2	0.2	-0.12	0.22	0.03	-0.022
B	2021	0.128	0.3	0.7	0.0	0.02	0.15	0.02	0.111
B	2022	0.138	0.3	0.7	0.0	-0.05	0.20	-0.01	0.125
B	2023	0.115	0.3	0.7	0.0	-0.12	0.22	0.03	0.118
C	2021	0.032	0.2	0.0	0.8	0.02	0.15	0.02	0.020
C	2022	-0.008	0.2	0.0	0.8	-0.05	0.20	-0.01	-0.018
C	2023	0.012	0.2	0.0	0.8	-0.12	0.22	0.03	0.000

- ▶ **Shares:** e.g., industry employment share: varying by location & industry (not time)
- ▶ **Shifts:** e.g., national industrial employment growth rate: varying by industry & time (not location)
- ▶ Suppose the economy experiences (i) a major decline in mfr and (ii) a boom in service
- ▶ Q1. What generates variation in  $z_{lt}$ ? Q2: Which part needs to be exogenous?

# Construction of a Shift-share IV

Version 2: Focus on one industry  $j$ . The inner product becomes an interaction term

$$z_{lt} = \underset{\text{share}_j}{S_{j,t_0}} \cdot \underset{\text{shift}_t}{g_{j,t}} \quad \text{or simply (suppress subscript), } z_{lt} = \underset{\text{share}_j}{S_l} \cdot \underset{\text{shift}_t}{g_t} \quad (3)$$

Consider a toy example 1: coal-mining phase-out similar to Krause 2024 JEEM

<i>location</i>	<i>year</i>	$x_{lt}$	$share_{coal}$	$shift_{coal}$	$z_{lt}$
A	2021	0.012	0.15	-0.08	-0.012
A	2022	-0.025	0.15	-0.15	-0.023
A	2023	-0.048	0.15	-0.25	-0.038
B	2021	0.002	0.02	-0.08	-0.002
B	2022	-0.005	0.02	-0.15	-0.003
B	2023	-0.008	0.02	-0.25	-0.005
C	2021	0.055	0.35	-0.08	-0.028
C	2022	-0.048	0.35	-0.15	-0.053
C	2023	-0.095	0.35	-0.25	-0.088

- ▶  $x_{lt}$ : various way to measure in coal employment in  $l$ 
  - ▶ Panel data regression: coal employment in  $l$  in year  $t$
  - ▶ Stacked 1-year FD: coal employment in  $l$  in year  $t - (t - 1)$
  - ▶ Long-FD: coal employment in  $l$  in year  $(t + h) - (t - 1)$
  - ▶ ES or LP-DID from a historical shock: coal employment in  $l$  in year 2016 - 2011
- ▶ **Share**: coal employment share in location  $l$  at a historical time (varying by  $l$ )
- ▶ **Shift**: national coal employment decline (varying by  $t$ )
- ▶ Q1. What generates variation in  $z_{lt}$ ? Q2: Which part needs to be exogenous?

# Construction of a Shift-share IV

Version 2: Focus on one industry  $j$ . The inner product becomes an interaction term

$$z_{lt} = \underset{\text{share}_j}{s_{j,t_0}} \cdot \underset{\text{shift}_t}{g_{j,t}} \quad \text{or simply (suppress subscript), } z_{lt} = \underset{\text{share}_l}{s_l} \cdot \underset{\text{shift}_t}{g_t} \quad (3)$$

Consider a toy example #2: oil boom & bust similar to Allcott & Keniston (2018) RES

location	year	$x_{lt}$	$share_{oil}$	$shift_{oil}$	$z_{lt}$
A	2010	0.085	0.08	0.45	0.036
A	2012	0.125	0.08	0.85	0.068
A	2014	0.042	0.08	-0.55	-0.044
B	2010	0.012	0.01	0.45	0.005
B	2012	0.018	0.01	0.85	0.009
B	2014	0.005	0.01	-0.55	-0.006
C	2010	0.225	0.25	0.45	0.113
C	2012	0.348	0.25	0.85	0.213
C	2014	0.082	0.25	-0.55	-0.138

- ▶  $x_{lt}$ : It could be a employment change in oil & gas industry  
In AK(2018), they ran the reduced-form regression directly (skipping 2SLS)
- ▶ **Share**: oil & gas employment share in location  $l$  in 2005 (varying by  $l$ )
- ▶ **Shift**: oil and gas growth rate (varying by  $t$ )
- ▶ Q1. What generates variation in  $z_{lt}$ ? Q2: Which part needs to be exogenous?

# Summary: Various Forms of Shift-share IVs

## V1 (inner product) and V2 (interaction)

Sometimes we can collect regional shift variables that may not vary at granular location  $l$  level but across broad region such as state  $s$

**V1. Construction IV as inner products of  $J$  number of industries (suppress subscript  $t_0$ )**

- a. typical format with national shift,  $z_{lt} = \sum_J s_{lj} \cdot g_{jt} = \sum_J \text{share}_{lj} \cdot \text{shift}_{jt}$
- b. when you observe regional shift,  $z_{lt} = \sum_J s_{lj} \cdot g_{sjt} = \sum_J \text{share}_{lj} \cdot \text{shift}_{sjt}$
- c. when you observe shift at  $l$  (unlikely),  $z_{lt} = \sum_J s_{lj} \cdot g_{ljt} = \sum_J \text{share}_{lj} \cdot \text{shift}_{ljt}$

**V2. Construct IV as an interaction (suppress subscript  $j$  and  $t_0$ )**

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- ▶ Of course if both share and shifts are exogenous, then your IV is super exogenous...
- ▶ Traditional, identification is from exogenous variation in "share"
- ▶ Recent development: exogenous variation in "shift" like an RCT (e.g., Borusyak et al. 2024)  
Example: local development in market/road access

# Summary: Various Forms of Shift-share IVs

If it happens your exogenous variation is from the "shift"

Sometimes we can collect regional shift variables that may not vary at granular location  $l$  level but across broad region such as state  $s$

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- ▶ It is recommended that after constructing  $z_{it}$ , perform a "re-center" (aka demean) procedure at the level when the shock takes place
- ▶ e.g., for national shock, demean  $z_{it}$  by year FE
- ▶ e.g., for state-level shock, demean  $z_{it}$  by state-by-year FE (but year FE is still acceptable)

# Outline

- ▶ Introduction: Bartik/Shift-share IVs ✓
- ▶ Example Krause (2026) JEEM

# Krause (2024) JEEM

## "Adjusting to the Energy Transition: Training & Transfers in Coal County"

**Research Question:** What's the effect of coal-mining industry phase-out during 2011-2016 affect local transfer payments and training investments in Appalachia areas?

Broad literature: Energy transition's effect on regional economy

- ▶ Energy transitions people study:
  - ▶ oil & gas boom and bust
  - ▶ natural gas boom (fracking)
  - ▶ coal-mining phase-out
  - ▶ retirement of coal-fired plants
  - ▶ entry & expansion of renewable energies
- ▶ Outcomes for regional economy that people study:
  - ▶ local labor market outcomes: employment, wage, job-to-job transition
  - ▶ local businesses: establishment counts, payroll
  - ▶ migration: population, in-, out-, net-migration
  - ▶ local public finance: transfer payments
  - ▶ local labor adjustment: migration, training, occupation change

# Krause (2024) "Coal Phase-out"

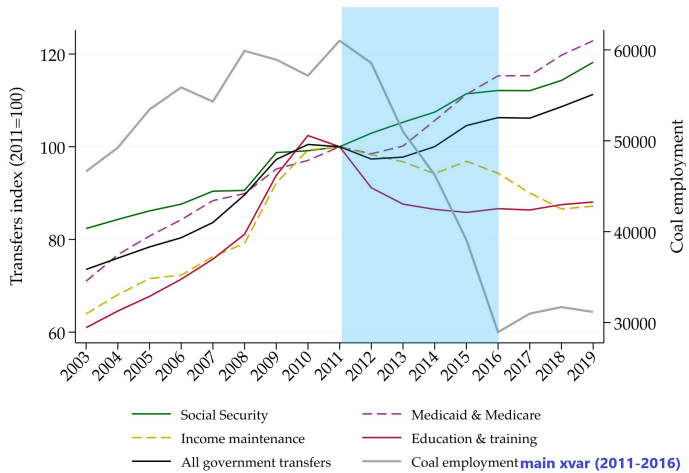
## Data

- ▶ Unit of an observation: a local labor market  $j$ 
  - ▶ typical definition: commuting zone (CZ) or county
  - ▶ usually CZ is preferred (see Tolbert & Sizer 1996 and Autor et al 2013 AER for explanation)
  - ▶ crosswalks that link PUMA code, county, etc to CZ ([link to public goods by David Dorn](#))
- ▶ Sample selection: Appalachia counties
  - ▶ Appalachian Regional Commission (ARC) has a list
  - ▶ Then aggregated these counties to CZ
- ▶ Key  $x$ var and  $iv$  are from
  - ▶ **individual mine's geo-code + employment** (Mine Safety and Health Administration, MSHA)
  - ▶ Then you can map mine to each CZ to compute CZ-level coal employment
  - ▶ CZ-level employment from QCEW
- ▶ Key  $y$ vars
  - ▶ transfer payments: BEA's REA (county level, aggregated to CZ)
  - ▶ training: Integrated Postsecondary Education Data System (IPEDS) from NCES

# Krause (2024) "Coal Phase-out"

Key xvar and yvar: aggregated trend in Appalachia

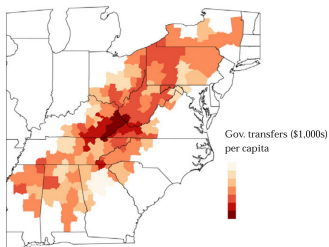
(a) Government transfers



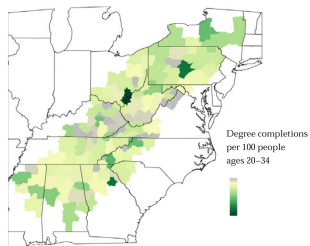
# Krause (2024) "Coal Phase-out"

Key yvars: cross-sectional variation

(a) Government transfers



(b) Degree completions



**Fig. 3.** Transfers and degree completions in 2011, Appalachian CZs. Notes: Left panel (a) presents total government transfers (in 1,000s of 2019 dollars) per capita, while right panel (b) presents total degree and certificate completions per 100 people ages 20–34. Completion data are from IPEDS, while transfer receipt is based on data from the BEA.





# Krause (2024) "Coal Phase-out"

## Main estimation equation

Typically, we would estimate

$$\Delta y_{j,t+h} = \beta_0 + \beta_1 \Delta \text{Coal}_{j,2011-16} + \beta_2 \mathbf{1}[\text{Coal}_{j,2011} > 0] + \beta_2 \mathbf{1}[\text{College}_j] + \gamma \mathbf{X}_j + \delta_r + \varepsilon_{it} \quad (1)$$

- ▶ Key xvar:  $\Delta \text{Coal}_{j,2011-16}$
- ▶ 16 separate regressions for  $h \in (-8, -7, \dots, 8)$  except based year 2011 ( $h = 0$ )
- ▶ Weighted by population in 2011  
This is common practice in all local-labor-market effect papers
- ▶ Controls in  $\mathbf{X}$ : BA share among adults, foreign-born share, female share of employment, mfr share of employment, population share for (20/20-64/65+), exposure to the Great Recession
- ▶ Reality check:  $X_{it}$  may not be exogenous, and you may need to look for IV
- ▶ Q1: Why there is no year FE?
- ▶ Q2: What's the TWFE version?
- ▶ Q3: What does the IV do here?

# Krause (2024) "Coal Phase-out"

Main results on transfer: for  $h = 5$  and  $h = 8$

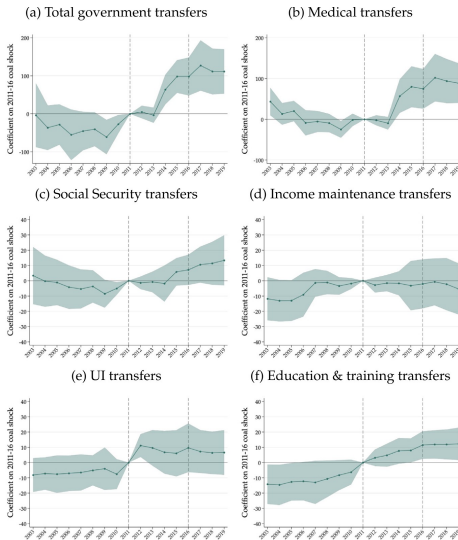
**Table A3**  
Government/Medical transfers: Controlling for state-level Medicaid expansion.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline specification		State fixed effects		Medicaid expansion		Medicaid*pop <150 % FPL	
	2011-16	2011-19	2011-16	2011-19	2011-16	2011-19	2011-16	2011-19
<b>Panel A: <math>\Delta</math> Government transfers per capita</b>								
$\Delta Coal_{j,2011-16}$	98.34*** (25.48)	111.5*** (29.83)	79.77*** (20.92)	91.32*** (28.67)	87.34*** (21.85)	102.3*** (28.05)	103.2*** (24.58)	121.6*** (34.39)
<b>Panel B: <math>\Delta</math> Medical transfers per capita</b>								
$\Delta Coal_{j,2011-16}$	74.84*** (24.76)	88.87*** (24.79)	52.16** (20.68)	68.99** (26.71)	58.39** (23.96)	73.62*** (25.51)	67.64*** (21.46)	83.31*** (25.21)
<b>Panel C: <math>\Delta</math> Medicaid transfers per capita</b>								
$\Delta Coal_{j,2011-16}$	66.43*** (23.55)	73.21*** (23.45)	48.94** (22.40)	64.69*** (23.48)	50.31** (25.08)	58.97** (26.46)	50.94** (21.75)	61.64*** (22.91)
Baseline controls	✓	✓	✓	✓	✓	✓	✓	✓
Medicaid dummy					✓	✓	✓	✓
Medicaid*FPL int.							✓	✓
Fixed effects	Region	Region	State	State	Region	Region	Region	Region
Observations	104	104	104	104	104	104	104	104

# Krause (2024) "Coal Phase-out"

Main results on transfer: for all  $h$

► Q4: How to study the mechanism?



# Krause (2024) "Coal Phase-out"

Results on earning: for  $h = 5$

**Table A4**

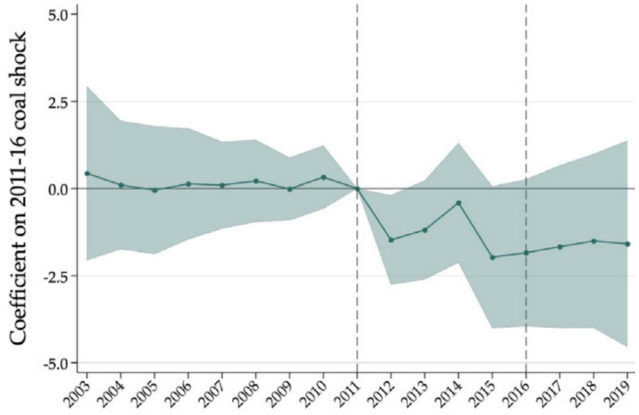
Change in earnings and decomposition of personal income per capita.

	(1)	(2)	(3)	(4)	(5)	(6)
	Earnings per worker		Income per capita			
	Wages & salaries per wage/salary worker	Total earnings per worker (all)	Total personal income per capita	Net earnings per capita	Dividends per capita	Govt transfers per capita
$\Delta Coal_{j,2011-16}$	-596.1*** (88.45)	-734.2*** (142.9)	-247.6** (116.9)	-409.3*** (117.8)	63.40** (26.40)	98.34*** (25.48)
Controls	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓
Observations	104	104	104	104	104	104

# Krause (2024) "Coal Phase-out"

Main results on degree completion: for all  $h$

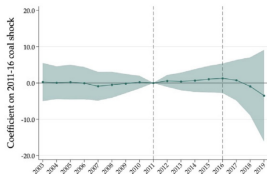
(a) All awards



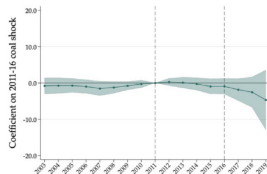
# Krause (2024) "Coal Phase-out"

Main results on enrollment: for all  $h$

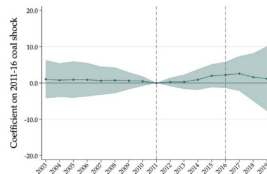
(a) Both 2- and 4-year institutions



(b) 2-year institutions



(c) 4-year institutions



**Fig. 6.** Effect of the 2011–2016 coal shock on FTE enrollment at postsecondary institutions per 1,000 people ages 20–34. Notes: Figure reflects the IV coefficient estimates of  $\beta_1$  in Eq. (1) and 95 percent confidence intervals for 16 separate regressions for each time difference between 2003–2011 and 2011–2019. The dependent variable is the change in full-time-equivalent (FTE) enrollees per 1,000 people ages 20–34 at the institution type indicated between 2011 and the year on the horizontal axis. The coal shock is defined as the 2011–2016 change in coal mining employment as a share of CZ employment in 2011, and is instrumented with the variable defined in Eq. (2). All regressions are weighted by the 2011 population and control for the 2011 college-educated share of adults, foreign-born share, female share of employment, manufacturing share of employment, exposure to the Great Recession defined in Eq. (3), population share under 20, 20–34, and 65 and older, Census region fixed effects, and dummy variables indicating whether the CZ had any coal employment in 2011 and whether the CZ hosted a postsecondary institution throughout the 2003–2019 period.

# Krause (2024)

## Some Qs from students

- ▶ T:  $\Delta \text{Coal}_{2011-2016}$ : A positive coefficient to reflect a decline in coal share of employment seems very counterintuitive
- ▶ C: I am confused as to why we need to instrument here when we have the observed employment change.
  - ▶ T: I think it is most commonly used in labor papers to truly isolate that the local effects are due to the bigger picture change, as opposed to a potential local labor shock that could've also impacted employment.
  - ▶ M: I think Tiara is correct. I remember that either the share or the shock needs to be exogenous. However, I am not sure if it is to isolate other local confounders, or if there is some national confounder that we don't want to influence the local results.
- ▶ M: I am confused about the reason for the shift-share instrument and how it works. I believe, but could be very wrong, that educational outcomes may be correlated with the national coal shock. However, the share of total employment that is coal mining in 2011 should not be correlated with educational outcomes past 2011. Are the authors using this interaction to say that the instrument allows the national shock to impact the cz by only the fraction of those employed as coal miners in 2011?
- ▶ T: Figure 4 show the main results for EQ 1. On a side note, it is interesting the way they chose to show it using a figure instead of a table.

# Krause (2024)

## Some Qs from students

- ▶ T: Even though the author ruled out the positive effects here, is it possible that the slight increase in enrollment was just basically balanced out by a subsequent increase in drop-outs?
  - ▶ C: I am not sure if the enrollment data includes drop outs or not. If so that could be the case. It is very interesting though that the 2-year coefficient goes negative over time even though it isn't significant.
- ▶ W: They find a null effect on post-secondary training enrollment despite the clear economic shock. Is this a supply or demand side issue? As in were the institutional capacities of the commuting zones unscalable or were workers accurately perceiving that retraining would not yield local returns?
- ▶ A: Did people stay away from schools because coal jobs would eventually come back?