Supplementary Materials

A Summary Statistics and Data Sources

A.1 Econometric Models

Table S1: Indicators and Data Sources

Indicator	Data Source	Survey/Dataset
Population Real GDP (chained 2017 USD) Real GDP per capita (chained 2017 USD)	US Department of Commerce Bureau of Economic Analysis (BEA)	Regional Economic Accounts
Labour Force Employed Persons Unemployed Persons Unemployment Rate	US Bureau of Labor Statistics (BLS)	Local Area Unemployment Statistics
Active mines	US Energy Information Administration (EIA) and the US Mine Safety and Health Administration (MSHA)	Mine Employment and Coal Production Data
Renewable Energy Investments	US Department of Agriculture	Energy Investment Report
County Adjacency Matrix	US Census Bureau	County Adjacency File

Table S2: Summary Statistics: Contiguous US Counties

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Active Mines	55,296	0.462	3.723	0	0	0	114
Unemployment Rate	55,296	6.130	2.720	0.800	4.200	7.500	29.400
Employed Persons	55,296	46,504	149,661	34	4,799	30,140	4,888,581
Unemployed Persons	55,296	2,993	11,183	3	293	1,988	621,950
Labour Force	55,296	49,498	159,938	38	5,128	32,055	5,122,843
Population	55,296	99,440	318,828	55	11,223	67,553	10,105,708
RE Investments (USD)*	55,296	114,142	2,670,894	0	0	0	250,000,000
Real GDP	55,296	5,140,646	22,046,739	7,648	342,473	2,550,861	726,943,301
Real GDP Per Capita	55,296	50.84	463.90	5.79	25.90	46.76	59,848.92
Rural-Urban Code	55,296	5.1	2.7	1	3	7	9
Rural-Urban (binary)	55,296	0.65	0.48	0	0	1	1
RE Inv. (prop. of Real GDP)**	55,296	0.091	3.073	0	0	0	504

*RE Investments (USD): Level of renewable energy investment in US dollars.
*RE Inv. (prop. of Real GDP): Level of renewable energy investment as proportion of county real GDP.

Table S3: Summary Statistics: US Coal Counties

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Active Mines	4,518	5.653	11.847	0	1	5	114
Unemployment Rate	4,518	6.946	2.520	2	5.2	8.3	21
Employed Persons	4,518	29,070	58,839	816	6,859	27,426	622,714
Unemployed Persons	4,518	1,933	3,535	32	477	1,890	46,564
Labour Force	4,518	31,003	62,187	870	7,392	29,621	651,926
Population	4,518	64,867	119,766	1,836	16,721	64,537	1,265,577
RE Investments (USD)*	4,518	27,056	333,440	0	0	0	10,005,017
Coal Production (short tons)	4,518	4,057,556	22,253,668	0	0	3,564,906	415,924,096
Real GDP	4,518	3,045,039	7,913,160	47,597	590,750	2,623,148	92,984,370
Real GDP Per Capita	4,518	41.688	25.763	8.221	26.348	48.551	244.161
Rural-Urban Code	4,518	5.116	2.376	1	3	7	9
Rural-Urban (binary)	4,518	0.697	0.460	0	0	1	1
TAA Allocation (USD)	4,518	14,597,789	20,533,595	0	0	23,427,230	117,476,517
RE Inv. (prop. of Real GDP)**	4,518	0.016	0.241	0	0	0	9

Table S4: Summary Statistics of Transformed Variables: Contiguous US Counties

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Δ Unemployment Rate	55,296	−0.061	1.228	−8.600	−0.700	0.300	13.500
Δ Active Mines_t	55,296	−0.015	0.605	−30	0	0	20
Δ (log) Real GDP	55,295	0.017	0.088	−1.122	−0.017	0.048	1.386
Δ (log) Real GDP per capita	55,295	0.014	0.088	−1.126	−0.020	0.043	1.391
Δ (log) Employed Persons	55,296	0.001	0.037	−0.596	−0.013	0.018	1.022
Δ (log) Unemployed Persons	55,296	−0.013	0.177	−0.852	−0.124	0.057	1.305
Δ (log) Labour Force	55,296	0.001	0.034	−0.562	−0.013	0.015	0.986
Δ (log) Population	55,295	0.003	0.014	−0.425	−0.005	0.009	0.290
REE $\geq$ 0.1% of GDP	55,296	0.127	0.333	0	0	0	1

Table S5: Summary Statistics of Transformed Variables: US Coal Counties Subset

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Δ Unemployment Rate	4,518	−0.056	1.322	−4.600	−0.793	0.400	8.300
Δ Active Mines_t	4,518	−0.182	2.109	−30	0	0	20
Δ (log) Real GDP	4,518	0.010	0.081	−0.604	−0.022	0.038	1.342
Δ (log) Real GDP per capita	4,518	0.010	0.080	−0.594	−0.021	0.037	1.351
Δ (log) Employed Persons	4,518	−0.002	0.035	−0.440	−0.015	0.014	0.214
Δ (log) Unemployed Persons	4,518	−0.014	0.179	−0.479	−0.120	0.051	1.077
Δ (log) Labour Force	4,518	−0.003	0.031	−0.396	−0.015	0.012	0.185
Δ (log) Population	4,518	−0.0004	0.010	−0.098	−0.006	0.004	0.066
REE $\geq$ 0.1% of GDP	4,518	0.097	0.296	0	0	0	1

A.2 Typology

Table S6: Indicators and Data Sources

Characteristic	Indicator	Data Source	Survey/Dataset
Rural vs. Urban	Rural-Urban Codes	US Department of Agriculture's Economic Research Service	Rural-Urban Continuum Codes 2013
Population Size	2019 Population Estimate	US Census Bureau	Population and Housing Unit Estimates
Educational Attainment	Percentage of population aged 25-64 with at least a bachelor's degree	US Census Bureau	American Community Survey
Economic Security	Median earnings (USD)	US Census Bureau	American Community Survey
Female Labor Force Participation Rate	Labor force participation rate of the female population aged 25-64 years	US Census Bureau	American Community Survey
Economic Diversity	Economic Diversity Index	Chmura Economics and Analytics	Economic Diversity Index
Political Attitudes	2016 and 2020 Election Returns	MIT Election Data and Science Lab	County Presidential Election Returns 2000-2020

Typology: Motivation for Indicator Choices

Summary: County demographic, social, economic, and political characteristics that have previously been identified as having potential to affect or determine an area's ability or potential to transition smoothly during and after and economic shift or shock were collected.

Rural vs. Urban: First, whether a county is more urban or rural can affect the proximity of newly unemployed workers formerly in brown industries to other job and education opportunities but will also impact identity construction surrounding extractive industries and limit accessibility to policymakers and other resources intended to support achieving a Just Transition (2).

Population Size: Second, population size is an important predictor of political reach and voice as well as economic activity and opportunities (11).

Educational Attainment: Third, the average level of educational attainment will impact qualifications and skill levels of individuals looking for new job opportunities, particularly in the face of a potential skills-biased structural decarbonisation. This may be of particular concern in resource-rich regions, as job opportunities presented in extractive industries and natural resource production have been found to provide a disincentive to education, especially among young men (7; 4).

Economic Security: Next, median earnings was used to proxy the level of economic security of a county. A lower level of economic security can imply great hardship for individuals and households facing periods of unemployment without savings to fall back on (5; 13).

Female Labor Force Participation Rate: Next, the coal mining industry, much like the fossil fuel industry overall, has a largely male-dominated workforce meaning the prospect of lay-offs of a male-dominated workforce will leave many households reliant on the income or labor of females (8). Therefore, boosting female employment in other industries might provide crucial income support during periods of transition for the implicated partners. This effect is proxied in the typology by female labor force participation among women between 25 and 64 years of age.

Economic Diversity: Furthermore, economic diversity, or the mix of industries providing employment within a county, is an important determinant not only of the proximate available job opportunities for workers to transition into but also potential sites of investment to boost economic opportunities, whether green or otherwise (19; 6; 12; 14).

Political Attitudes: Lastly, political attitudes or party affiliation will not only dictate the generosity of public support measures but also the type of messaging surrounding transitions that will either corrode or boost public support and willingness to engage with implemented support measures (1; 17; 2). Furthermore, as ambitions relating to environmental regulation as well as investments in renewable energy and energy efficiency industries are generally advanced by the US Democratic party, political party affiliation will likely dictate the kinds of opportunities that will be created for fossil fuel workers facing unemployment risks. Originally, political attitudes were intended to be proxied by county returns in the 2016 and 2020 presidential elections (10). However, only 19 of 252 coal counties voted for the Democratic party in the 2016 and 2020 presidential elections and this was therefore excluded from the clustering analysis as Republican party affiliation seems to be a unifying characteristic among coal counties.

Table S7: Summary Statistics: Stylized Typology Characteristics

Statistic	N*	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
2013 Rural-Urban Code	252	5.1	2.4	1	3	7	9
Population Size	252	64,655.3	121,468.2	1,959	16,684.5	64,320.2	1,216,045
Educational Attainment (%; aged 25-64)	252	18.2	7.7	5.4	13.6	20.7	56.2
Median Earnings (USD)	252	34,204.2	4,935.0	20,268	31,357	36,705.2	54,754
Female Labour Force Participation (%; aged 25-64)	252	64.6	8.9	37.9	60.3	71.1	81.7
Chmura Diversity Index	252	1.0	0.2	0.5	0.9	1.1	1.5
Voted for the Republican Party in the 2020 Election	252	0.9	0.3	0	1	1	1
Voted for the Republican Party in the 2016 Election	252	0.9	0.3	0	1	1	1

Note: The state of Virginia's counties are measured differently across data sources. More precisely, the BEA combines independent cities of Virginia with adjacent counties thus reporting less county observations than in the remaining data sources. For the econometric applications, this discrepancy was overcome by adjusting the remaining data sources to match the county identification codes provided by the BEA. Conventional FIPS codes were used for the typology analysis to allow for the inclusion of the relevant indicators with minimal additional manipulation. Only one county retained in the typology analysis is implicated in the BEA-Census Bureau discrepancy, thus the impact of this choice on the results is deemed minimal. Therefore, in the subsequent analysis, econometric applications make use of 3,072 county observations versus the 3,107 counties observed in the typology dataset. Additionally, for the subset of coal counties, the number of counties included in the typology (252) differs from the number identified in the econometric analysis (251) because Wise County, Virginia and Norton City, Virginia are considered separately by the various entities reporting data for the typology characteristics. They are combined into one county area by the Bureau of Economic Analysis whose method was adopted as the standard for the econometric analysis.

Alaska, Hawaii, and the District of Columbia (DC) were excluded from the analysis. Hawaii does not produce coal. Indicators for DC are inconsistently reported across the datasets involved in this analysis. During the 18-year time period analyzed, Alaska's county equivalents were divided and re-grouped making it difficult to compare available data between time periods. The exclusion of DC is considered a limitation in this work.

B Econometric Models

B.1 Two-way fixed effects (TWFE) OLS models

Table S8: Impact of change in active mines on the change in county employment indicators (log excl. UER)
Using a TWFE OLS regression model on all contiguous US counties

Dependent Variables:	Δ Unemployment Rate	Δ Employed Persons (log)	Δ Unemployed Persons (log)	Δ Labour Force (log)	Δ Population (log)
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Δ Active Mines$_t$	-0.0563***	0.0011*	-0.0055**	0.0005	-4.5×10^{-5}
	(0.0141)	(0.0004)	(0.0016)	(0.0003)	(7.38×10^{-5})
Δ Active Mines$_{t-1}$	-0.0070	0.0016***	-0.0003	0.0016***	0.0001
	(0.0136)	(0.0003)	(0.0014)	(0.0003)	(6.61×10^{-5})
Δ Active Mines$_{t-2}$	0.0389**	0.0004	0.0036.	0.0009.	0.0002*
	(0.0125)	(0.0004)	(0.0018)	(0.0004)	(7.04×10^{-5})
Δ (log)Real GDPPC$_t$	-0.9738***				
	(0.2137)				
Δ (log)Real GDP$_t$		0.0514***	-0.1025***	0.0409***	0.0076***
		(0.0067)	(0.0196)	(0.0051)	(0.0016)
Δ (log)Population$_t$		0.5302***	0.9293***	0.5543***	
		(0.0634)	(0.1869)	(0.0598)	
Fixed-effects					
County FIPS Code	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	55,295	55,295	55,295	55,295	55,295
R^2	0.61338	0.20841	0.65143	0.18310	0.44840
Within R^2	0.01470	0.04780	0.01637	0.05150	0.00377

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S9: Impact of change in active mines on changes in county employment indicators (log excl. UER)
Using a TWFE OLS regression model on US coal counties

Dependent Variables:	Δ Unemployment Rate	Δ Employed Persons (log)	Δ Unemployed Persons (log)	Δ Labour Force (log)	Δ Population (log)
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Δ Active Mines_{t}	-0.0413**	0.0008.	-0.0037*	0.0003	-4.21×10^{-5}
	(0.0124)	(0.0004)	(0.0013)	(0.0003)	(5.96×10^{-5})
Δ Active $\text{Mines}_{\text{t-1}}$	-0.0042	0.0013***	0.0002	0.0013***	5.8×10^{-5}
	(0.0099)	(0.0003)	(0.0010)	(0.0003)	(6.04×10^{-5})
Δ Active $\text{Mines}_{\text{t-2}}$	0.0338**	0.0004	0.0035*	0.0008*	0.0001*
	(0.0101)	(0.0004)	(0.0015)	(0.0004)	(5.54×10^{-5})
Δ (log)Real GDPPC_{t}	-1.588***				
	(0.3504)				
Δ (log)Real GDP_{t}		0.0650***	-0.1615**	0.0473***	0.0054.
		(0.0122)	(0.0409)	(0.0102)	(0.0027)
Δ (log)$\text{Population}_{\text{t}}$		0.7066***	1.046	0.7134***	
		(0.1054)	(0.6443)	(0.0938)	
Fixed-effects					
County FIPS Code	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	4,518	4,518	4,518	4,518	4,518
R^2	0.65485	0.25173	0.68570	0.22373	0.49417
Within R^2	0.04538	0.06787	0.03124	0.06505	0.00538

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S10: Asymmetric treatment on all US counties

Performed using a TWFE OLS regression on all contiguous US counties.

Dependent Variable:	Δ Unemployment Rate		
Model:	(1)	(2)	(3)
Variables			
Δ Active Mines$_{\mathrm{t}}$	-0.0193	-0.0752**	
	(0.0201)	(0.0235)	
Δ Active Mines$_{\mathrm{t-1}}$	0.0221	-0.0301	
	(0.0285)	(0.0219)	
Δ Active Mines$_{\mathrm{t-2}}$	0.0090	0.0546***	
	(0.0236)	(0.0116)	
Δ (log) Real GDPPC$_{\mathrm{t}}$	-0.9724***	-0.9724***	-0.9724***
	(0.2138)	(0.2138)	(0.2138)
Δ Active Mines$_{\mathrm{t}}$ $\times$ $\Delta_{negative_t}$	-0.0559		-0.0752**
	(0.0370)		(0.0235)
Δ Active Mines$_{\mathrm{t-1}}$ $\times$ $\Delta_{negative_{t-1}}$	-0.0521		-0.0301
	(0.0422)		(0.0219)
Δ Active Mines$_{\mathrm{t-2}}$ $\times$ $\Delta_{negative_{t-2}}$	0.0457		0.0546***
	(0.0277)		(0.0116)
Δ Active Mines$_{\mathrm{t}}$ $\times$ $\Delta_{positive_t}$		0.0559	-0.0193
		(0.0370)	(0.0201)
Δ Active Mines$_{\mathrm{t-1}}$ $\times$ $\Delta_{positive_{t-1}}$		0.0521	0.0221
		(0.0422)	(0.0285)
Δ Active Mines$_{\mathrm{t-2}}$ $\times$ $\Delta_{positive_{t-2}}$		-0.0457	0.0090
		(0.0277)	(0.0236)
Fixed-effects			
County FIPS Code	Yes	Yes	Yes
Year	Yes	Yes	Yes
Fit statistics			
Observations	55,295	55,295	55,295
R^2	0.61355	0.61355	0.61355
Within R^2	0.01513	0.01513	0.01513

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S11: Asymmetric treatment on subset of US coal counties

Performed using a TWFE OLS regression on US coal counties.

Dependent Variable:	ΔUnemployment Rate		
Model:	(1)	(2)	(3)
Variables			
Δ Active Mines$_{\mathrm{t}}$	-0.0193	-0.0752**	
	(0.0201)	(0.0235)	
ΔActive Mines$_{\mathrm{t\text{-}1}}$	0.0221	-0.0301	
	(0.0285)	(0.0219)	
ΔActive Mines$_{\mathrm{t\text{-}2}}$	0.0090	0.0546***	
	(0.0236)	(0.0116)	
Δ (log) Real GDPPC$_{\mathrm{t}}$	-0.9724***	-0.9724***	-0.9724***
	(0.2138)	(0.2138)	(0.2138)
Δ Active Mines$_{\mathrm{t}}$ $\times$ $\Delta_{negative_t}$	-0.0559		-0.0752**
	(0.0370)		(0.0235)
Δ Active Mines$_{\mathrm{t\text{-}1}}$ $\times$ $\Delta_{negative_{t-1}}$	-0.0521		-0.0301
	(0.0422)		(0.0219)
Δ Active Mines$_{\mathrm{t\text{-}2}}$ $\times$ $\Delta_{negative_{t-2}}$	0.0457		0.0546***
	(0.0277)		(0.0116)
Δ Active Mines$_{\mathrm{t}}$ $\times$ $\Delta_{positive_t}$		0.0559	-0.0193
		(0.0370)	(0.0201)
Δ Active Mines$_{\mathrm{t\text{-}1}}$ $\times$ $\Delta_{positive_{t-1}}$		0.0521	0.0221
		(0.0422)	(0.0285)
Δ Active Mines$_{\mathrm{t\text{-}2}}$ $\times$ $\Delta_{positive_{t-2}}$		-0.0457	0.0090
		(0.0277)	(0.0236)
Fixed-effects			
County FIPS Code	Yes	Yes	Yes
Year	Yes	Yes	Yes
Fit statistics			
Observations	55,295	55,295	55,295
R^2	0.61355	0.61355	0.61355
Within R^2	0.01513	0.01513	0.01513

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

B.1.1 Linear Hypothesis Tests of Contemporaneous and Persistent Effects

The following tables show the results for a set of linear hypothesis tests testing whether the contemporaneous effect and linear combination of the contemporaneous and time-lagged effects are zero. Our null hypothesis is described in the second column of Table S12 referencing the β values represented in the following equations. The results for these regression equations are reported in above Table S10.

Table S12: General Linear Hypothesis Test Results

Estimation		Main model		Negative Treatment		Positive Treatment	
Test	Null Hypothesis	(1)	(2)	(3)	(4)	(5)	(6)
Contemporaneous Effect	$\beta_1 = 0$	-0.056***					
SE		(0.014)					
p-value		(<0.001)					
Persistent Effect	$\beta_1 + \beta_2$		-0.024				
SE	$+\beta_3 = 0$		(0.027)				
p-value			(0.364)				
Contemporaneous Effect	$\beta_1 + \beta_4 = 0$			-0.075**			
SE				(0.023)			
p-value				(0.001)			
Persistent Effect	$\beta_1 + \beta_2 + \beta_3 +$				-0.051		
SE	$\beta_4 + \beta_5 + \beta_6 = 0$				(0.031)		
p-value					(0.101)		
Contemporaneous Effect	$\beta_1 + \beta_7 = 0$					-0.019	
SE						(0.020)	
p-value						(0.336)	
Persistent Effect	$\beta_1 + \beta_2 + \beta_3 +$						0.012
SE	$\beta_7 + \beta_8 + \beta_9 = 0$						(0.057)
p-value							(0.838)

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

$$\Delta UER_{it} = \beta_1 \Delta ActiveMines_{\text{it}} + \beta_2 \Delta ActiveMines_{\text{it-1}} + \beta_3 \Delta ActiveMines_{\text{it-2}} + \beta . \Delta log(RealGDPPC)_{it} + \alpha_i + \gamma_t + \varepsilon_{it}$$

$$\Delta UER_{it} = \beta_1 \Delta ActiveMines_{\text{it}} + \beta_2 \Delta ActiveMines_{\text{it-1}} + \beta_3 \Delta ActiveMines_{\text{it-2}} + \beta_4 \Delta ActiveMines_{it} \times \Delta_{negative_{it}} + \beta_5 \Delta ActiveMines_{it-1} \times \Delta_{negative_{it-1}} + \beta_6 \Delta ActiveMines_{\text{t-2}} \times \Delta_{negative_{t-2}} + \beta_{.} \Delta log(RealGDPPC)_{it} + \alpha_i + \gamma_t + \varepsilon_{it}$$

$$\Delta UER_{it} = \beta_1 \Delta ActiveMines_{\text{it}} + \beta_2 \Delta ActiveMines_{\text{it-1}} + \beta_3 \Delta ActiveMines_{\text{it-2}} + \beta_7 \Delta ActiveMines_{it} \times \Delta_{positive_{it}} + \beta_8 \Delta ActiveMines_{it-1} \times \Delta_{positive_{it-1}} + \beta_9 \Delta ActiveMines_{\text{t-2}} \times \Delta_{positive_{t-2}} + \beta_{.} \Delta log(RealGDPPC)_{it} + \alpha_i + \gamma_t + \varepsilon_{it}$$

B.2 Spatial Models

Table S13: Impacts of Spatial Error-Lag Model

	Outcome Variable: ΔUnemployment Rate							
	Δ Active Mines_{t}		Δ Active $\text{Mines}_{\text{t-1}}$		Δ Active $\text{Mines}_{\text{t-2}}$		Δ (log) Real GDPPC_{t}	
	Estimate	Sim. SE	Estimate	Sim. SE	Estimate	Sim. SE	Estimate	Sim. SE
Direct	-0.036***	0.004	-0.008.	0.004	0.027***	0.004	-0.550***	0.027
Indirect	-0.215***	0.027	-0.045.	0.025	0.163***	0.028	-3.308***	0.191
Total	-0.250***	0.032	-0.053.	0.029	0.190***	0.032	-3.858***	0.217

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S14: Impacts of Spatial Lag Model

	Outcome Variable: ΔUnemployment Rate							
	Δ Active Mines_{t}		Δ Active $\text{Mines}_{\text{t-1}}$		Δ Active $\text{Mines}_{\text{t-2}}$		Δ (log) Real GDPPC_{t}	
	Estimate	Sim. SE	Estimate	Sim. SE	Estimate	Sim. SE	Estimate	Sim. SE
Direct	-0.036***	0.005	-0.009.	0.005	0.028***	0.005	-0.651***	0.032
Indirect	-0.082***	0.012	-0.020.	0.011	0.064***	0.010	-1.490***	0.080
Total	-0.118***	0.017	-0.029.	0.016	0.091***	0.015	-2.141***	0.111

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S15: Coefficient Estimates of Spatial Error Model

	ΔUnemployment Rate
Variables	
Spatial error parameter (ρ)	0.742***
	(0.004)
Δ Active Mines$_{\mathrm{t}}$	-0.026***
	(0.004)
Δ Active Mines$_{\mathrm{t-1}}$	-0.009*
	(0.004)
Δ Active Mines$_{\mathrm{t-2}}$	0.021***
	(0.004)
Δ (log) Real GDPPC$_{\mathrm{t}}$	-0.543***
	(0.03)

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S16: Coefficient Estimates of Durbin Spatial Error Model

	ΔUnemployment Rate
Variables	
Spatial error parameter (ρ)	0.741***
	(0.004)
Δ Active Mines$_{\mathrm{i}}$	-0.035***
	(0.005)
Δ Active Mines$_{\mathrm{i,t-1}}$	-0.01*
	(0.005)
Δ Active Mines$_{\mathrm{i,t-2}}$	0.026***
	(0.004)
Δ (log) Real GDPPC	-0.543***
	(0.03)
Δ Active Mines$_{\mathrm{-i}}$	-0.055***
	(0.013)
Δ Active Mines$_{\mathrm{-i,t-1}}$	-0.004
	(0.012)
Δ Active Mines$_{\mathrm{-i,t-2}}$	0.032**
	(0.012)

Table S17: Spatial Model Comparison by Criterion

	Log Likelihood	AIC	BIC
Spatial Lag-Error Model	-127,721.6	261,635.3	289,253.0
Spatial Lag Model	-272,367.1	550,924.2	578,533.0
Spatial Error Model	-272,426.2	551,042.3	578,651.1

Table S18: Impacts of Spatial Lag-Error (SARAR) models of overall county economy employment indicators

	Δ (log) Employed Persons			Δ (log)Unemployed Persons		
	Direct	Indirect	Total	Direct	Indirect	Total
Δ Active Mines$_{t}$	0.001**	0.002**	0.002**	-0.003***	-0.022***	-0.026***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.004)	(0.005)
Δ Active Mines$_{t-1}$	0.001***	0.003***	0.004***	0.000	-0.002	-0.003
	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	(0.004)
Δ Active Mines$_{t-2}$	0.000	0.000	0.001	0.003***	0.017***	0.019***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	(0.004)
Δ (log) Real GDP	0.037***	0.082***	0.119***	-0.058***	-0.382***	-0.44***
	(0.001)	(0.004)	(0.005)	(0.004)	(0.027)	(0.031)
Δ (log) Population	0.414***	0.925***	1.339***	0.67***	4.399***	5.069***
	(0.012)	(0.038)	(0.047)	(0.033)	(0.249)	(0.279)

	Δ (log)Labour Force			Δ (log)Population		
	Direct	Indirect	Total	Direct	Indirect	Total
Δ Active Mines$_{t}$	0.000	0.001	0.001	0.000	0.000	0.000
	(0.000)	(0.000)	0.001	(0.000)	(0.000)	(0.000)
Δ Active Mines$_{t-1}$	0.001***	0.002***	0.003***	0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Δ Active Mines$_{t-2}$	0.001**	0.001**	0.002**	0.000*	0.000*	0.000*
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Δ (log) Real GDP	0.030***	0.061***	0.091***	0.005***	0.012***	0.017***
	(0.001)	(0.003)	(0.004)	(0.000)	(0.001)	(0.002)
Δ (log) Population	0.437***	0.890***	1.328***			
	(0.011)	(0.036)	(0.045)			

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

B.3 Heterogeneous Trends Models

Table S19: Coefficient estimates of 1- and 2-factor models

	(1)	(2)
	ΔUnemployment Rate	
Variables		
Δ Active Mines_t	-0.065***	-0.065***
	(0.006)	(0.007)
Δ Active Mines_{t-1}	-0.007	-0.007
	(0.006)	(0.006)
Δ Active Mines_{t-2}	0.037***	0.037***
	(0.006)	(0.006)
Δ (log) Real GDPPC_t	-0.941***	-0.941***
	(0.042)	(0.043)
R^2	0.384	0.193
Additive Effects Type:	two-ways	two-ways
# Unobserved Factors Used:	1	2

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S20: Coefficient estimates of 1-factor models of each county employment/economy indicator

Variables	Δ Employed Persons (log)	Δ Unemployed Persons (log)	Δ Labour Force (log)	Δ Population (log)
Δ Active Mines_t	0.001***	-0.006***	0.000.	0.000
	(0.000)	(0.001)	(0.000)	(0.000)
Δ Active Mines_{t-1}	0.002***	0.000	0.002***	0.000
	(0.000)	(0.001)	(0.000)	(0.000)
Δ Active Mines_{t-2}	0.000	0.004***	0.001***	0.000
	(0.000)	(0.001)	(0.000)	(0.000)
Δ (log) Real GDP	0.049***	-0.100***	0.038***	0.004***
	(0.002)	(0.006)	(0.002)	(0.001)
Δ(log) Population	0.495***	0.775***	0.508***	
	(0.016)	(0.048)	(0.014)	
R^2	0.246	0.323	0.217	0.501
Additive Effects Type	two-ways	two-ways	two-ways	two-ways
# Unobserved Factors Used	1	1	1	1

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

C Testing

C.1 Cross-sectional & spatial dependence tests

Table S21: Results for Model 1

Test	Test Statistic	P-value	Alternative Hypothesis	Outcome
Pesaran CD test	291.6	0***	Cross-sectional dependence	Validated*
Breusch-Pagan LM test	90,361	0***	Cross-sectional dependence	Validated
Scaled LM test	600	0***	Cross-sectional dependence	Validated*
Average correlation coefficient	0.7181	N/A	Cross-sectional dependence	Validated*
Average absolute correlation coefficient	0.7192	N/A	Cross-sectional dependence	Validated

* Results confirmed by randomisation-based versions of the relevant test robust to global dependence by common factors and persistence in the data.

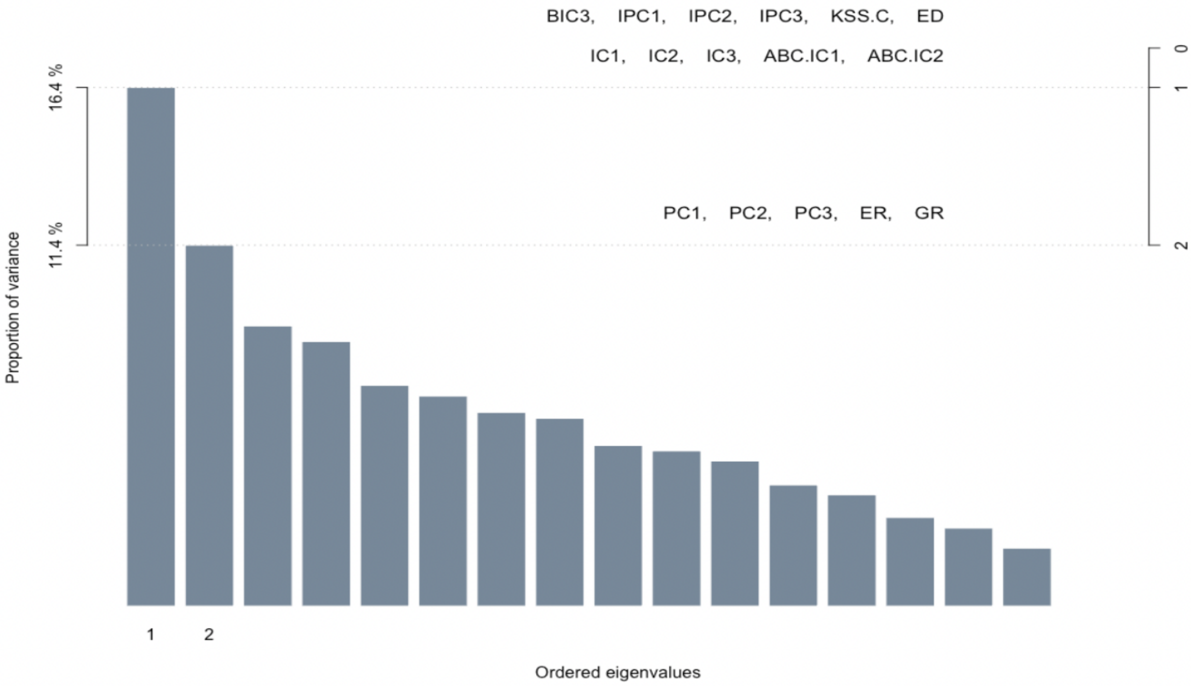
Table S22: Testing for Spatial Dependence in Residuals of Model 1 & Models $1^{[\mathrm{SLX,\ SEM,\ SLM,\ SARAR}]}$

Model #	Method	Test Statistic	P-value	Alternative Hypothesis
Model 1	Pesaran CD test	43.928	0.000	Cross-sectional dependence
	Average correlation coefficient	0.005	N/A	Cross-sectional dependence
Model 1^{SLX}	Pesaran CD test	-2.370	0.018	Cross-sectional dependence
	Average correlation coefficient	0.000	N/A	Cross-sectional dependence
Model 1^{SEM}	Pesaran CD test	-2.399	0.016	Cross-sectional dependence
	Average correlation Coefficient	0.000	N/A	cross-sectional dependence
Model 1^{SLM}	Pesaran CD test	-2.098	0.036	Cross-sectional dependence
	Average correlation coefficient	0.000	N/A	Cross-sectional dependence
Model 1^{SARAR}	Pesaran CD test	-2.029	0.042	Cross-sectional dependence
	Average correlation coefficient	0.000	N/A	Cross-sectional dependence

Ideally, a Moran's I test would be implemented to determine the degree of residual spatial dependence in each of the spatial models. Unfortunately, such a method in R only exists for cross-sectional data and not panel data. As an imperfect alternative, we applied Pesaran's cross-sectional dependence test to the residuals of each spatial model (as well as the residuals of Model 1). This revealed a small degree of remaining spatial dependence. However, we are only able to reject the null hypothesis of no cross-sectional dependence at a 5% level of significance for each spatial model as compared to a less than 0.01% level of significance in Model 1 without spatial components. The average correlation coefficient is also near 0 for the residuals of each spatial model, whereas the average correlation coefficient of the residuals of Model 1 is 0.005.

C.2 Optimal factor choice testing for heterogeneous trends models

Figure S1: Scree Plot: Optimal Factor Choices Reported by Various Factor/Principal Component Analysis Methods



C.3 Optimal cluster choice for typology construction

Figure S2: Optimal Cluster (k) Choice: Within Cluster Sum of Squares (Elbow Method)

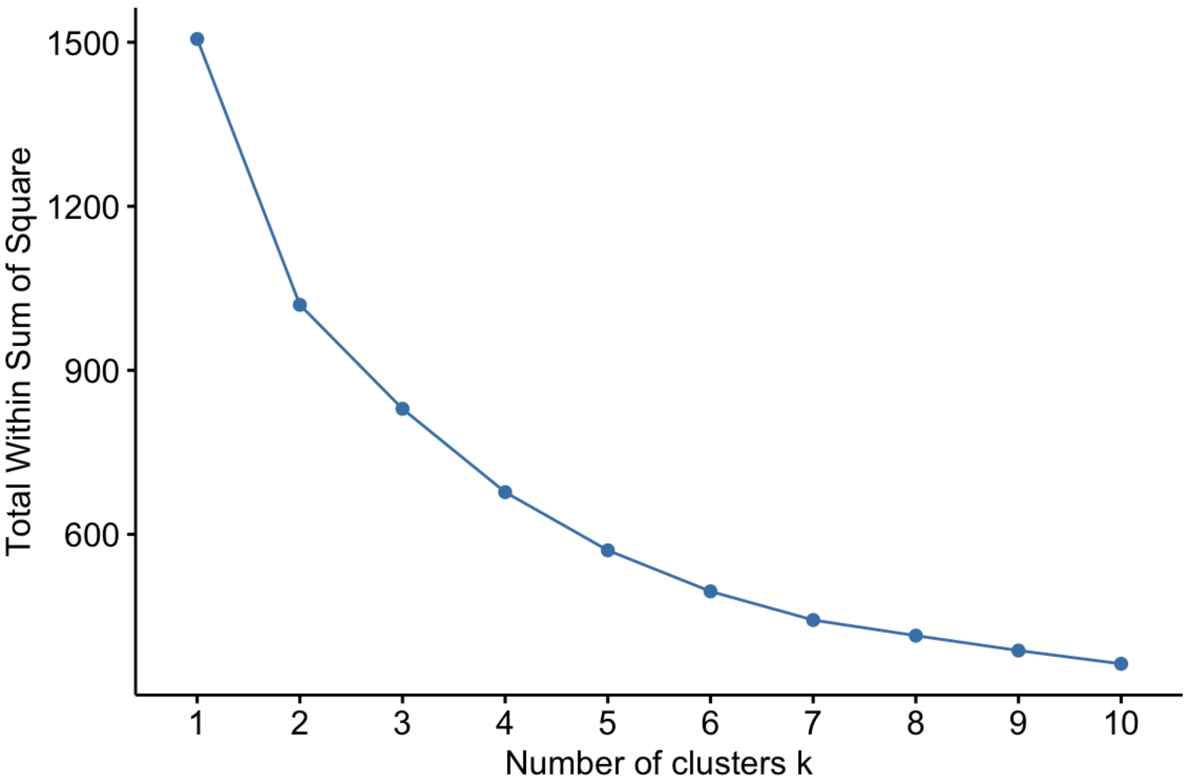


Figure S3: Optimal Cluster (k) Choice: Average Silhouette Method

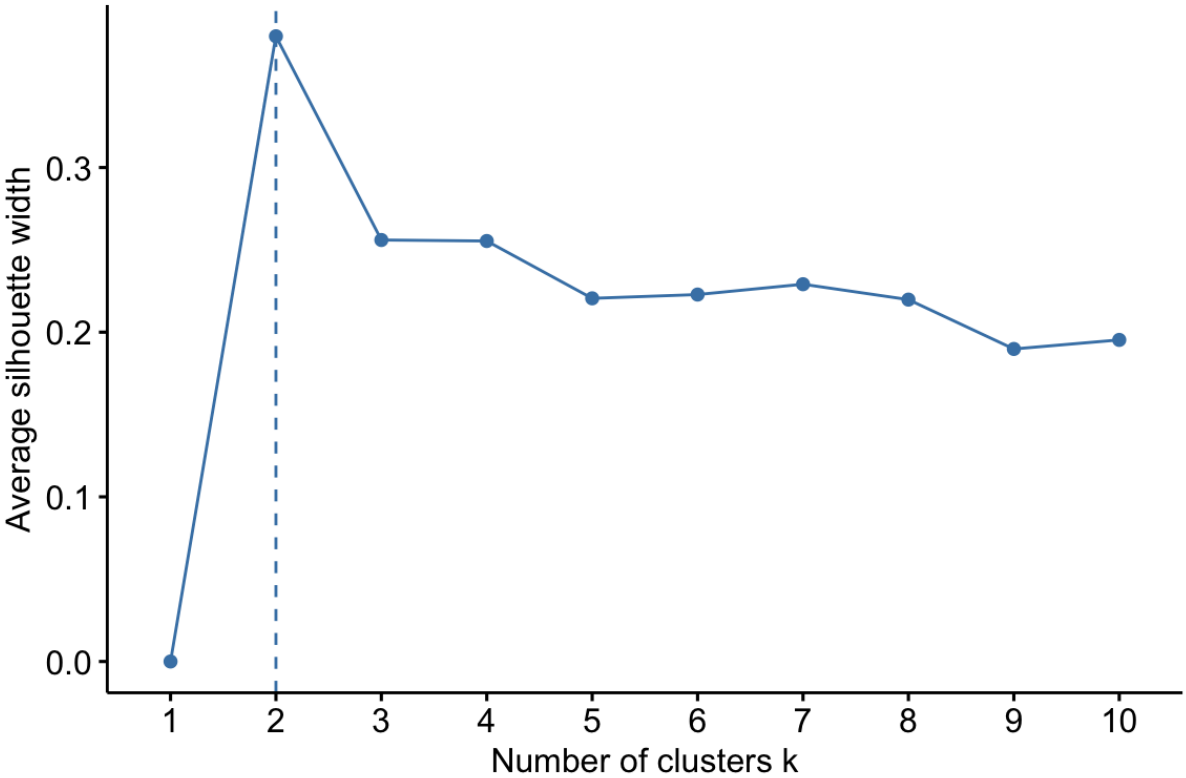
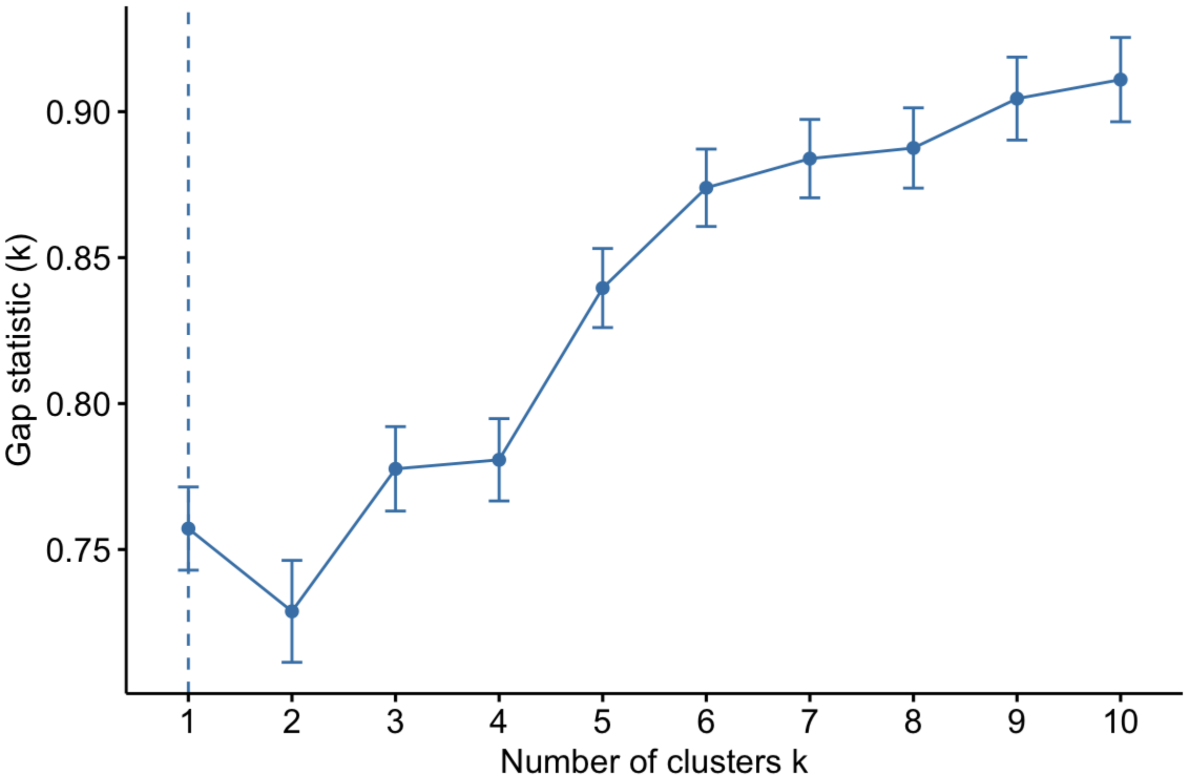


Figure S4: Optimal Cluster (k) Choice: Gap Statistic



D Typology

D.1 Typology clustering results

Table S23: Typology of US Coal Counties

	Type 1	*Type 2*	*Type 3*	*US Average*
Rural vs. Urban	2.5 (Metro)	5.3 (Nonmetro)	7.3 (Rural/Nonmetro)	5.0 (Nonmetro)
Population	194,262	36,100	19,143	104,727
Educational attainment	29.1%	16.5%	11.4%	21.9%
Median earnings	$38,686	$33,948	$29,845	$35,826
Female labor force participation rate	72.7%	66.1%	49.2%	69.7%
Economic Diversity Index	High/ Medium	Medium/ Low	Low	Medium
# counties that voted for the Republican Party in the 2020 presidential election	36	156	41	2,568
# counties that voted for the Republican Party in the 2016 presidential election	36	156	41	2,623
Total number of counties per type	*50*	*160*	*42*	*3,107*

D.2 Incorporating the typology into the econometric models

Table S24: Impact of change in active mines on county employment indicators
Allowing for slope heterogeneity of treatment variables

Dependent Variable:	ΔUnemployment Rate	
Model:	(1)	(2)
Variables		
Type 1 $\times$ Δ Active Mines$_{t+1}$		-0.0141
		(0.0133)
Type 2 $\times$ Δ Active Mines$_{t+1}$		-0.0184
		(0.0121)
Type 3 $\times$ Δ Active Mines$_{t+1}$		-0.0181
		(0.0256)
Type 1 $\times$ Δ Active Mines$_{t}$	-0.0063	-0.0088
	(0.0172)	(0.0175)
Type 2 $\times$ Δ Active Mines$_{t}$	-0.0088	-0.0113
	(0.0084)	(0.0092)
Type 3 $\times$ Δ Active Mines$_{t}$	-0.0598**	-0.0609**
	(0.0167)	(0.0174)
Type 1 $\times$ Δ Active Mines$_{t-1}$	-0.0236	-0.0250
	(0.0154)	(0.0162)
Type 2 $\times$ Δ Active Mines$_{t-1}$	0.0016	0.0001
	(0.0102)	(0.0097)
Type 3 $\times$ Δ Active Mines$_{t-1}$	-0.0042	-0.0049
	(0.0133)	(0.0151)
Type 1 $\times$ Δ Active Mines$_{t-1}$	-0.0267$^{\cdot}$	-0.0294*
	(0.0129)	(0.0138)
Type 2 $\times$ Δ Active Mines$_{t-2}$	0.0242$^{\cdot}$	0.0261$^{\cdot}$
	(0.0131)	(0.0131)
Type 3 $\times$ Δ Active Mines$_{t-2}$	0.0468***	0.0473**
	(0.0108)	(0.0126)
Type 1 $\times$ Δ Active Mines$_{t-3}$		-0.0117
		(0.0119)
Type 2 $\times$ Δ Active Mines$_{t-3}$		0.0060
		(0.0061)
Type 3 $\times$ Δ Active Mines$_{t-3}$		0.0049
		(0.0107)
Δ (log) Real GDPPC$_{t}$	-1.577***	-1.588***
	(0.3474)	(0.3561)
Fixed-effects		
County FIPS Code	Yes	Yes
Year	Yes	Yes
Fit statistics		
Observations	4,518	4,267
R^2	0.65772	0.66275
Within R^2	0.05330	0.05772

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

E Robustness Checks & Additional Analysis

E.1 Varying Levels, First-differences, and Lags in TWFE OLS Models

E.1.1 Level Indicators

Table S25: Impact of the number of active mines on county unemployment rate (level)
Using a TWFE OLS regression model with various combinations of time lags and leads

Dependent Variable:	Unemployment Rate					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
	All US Counties			Coal Counties Only		
Variables						
Active Mines_{t+3}			-0.0284.			-0.0177
			(0.0134)			(0.0116)
Active Mines_{t+2}		-0.0293*	-0.0030		-0.0220.	-0.0059
		(0.0127)	(0.0033)		(0.0115)	(0.0042)
Active Mines_{t+1}		-0.0164	-0.0150		-0.0173	-0.0168
		(0.0150)	(0.0138)		(0.0137)	(0.0131)
Active Mines	-0.0938***	-0.0585*	-0.0620**	-0.0740***	-0.0446*	-0.0468*
	(0.0202)	(0.0206)	(0.0187)	(0.0178)	(0.0172)	(0.0161)
Active Mines_{t-1}	-0.0051	-0.0053	-0.0084	-0.0046	-0.0055	-0.0085
	(0.0159)	(0.0115)	(0.0105)	(0.0143)	(0.0103)	(0.0095)
Active Mines_{t-2}	0.0425***	0.0456***	0.0353***	0.0360***	0.0404***	0.0306***
	(0.0106)	(0.0090)	(0.0056)	(0.0091)	(0.0089)	(0.0041)
Active Mines_{t-3}	0.0259*		0.0059	0.0227*		0.0074
	(0.0102)		(0.0093)	(0.0099)		(0.0090)
(log) Real GDPPC_t	-0.9987**	-1.283***	-1.473***	-1.118***	-1.367***	-1.542***
	(0.2558)	(0.3114)	(0.3444)	(0.2559)	(0.2884)	(0.3149)
Fixed-effects						
County FIPS Code	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	55,296	49,152	46,080	4,518	4,016	3,765
R^2	0.84475	0.84904	0.85296	0.85387	0.85524	0.85904
Within R^2	0.02682	0.04056	0.04970	0.09054	0.12315	0.13941

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S26: Impact of the number of active mines on county employment indicators (levels)
Using a TWFE OLS regression model with two time lags on all contiguous US counties

Dependent Variables:	Employed Persons	Unemployed Persons	Labour Force	Population
Model:	(1)	(2)	(3)	(4)
Variables				
Active Mines	12.69	-1.205	11.48	206.3*
	(31.64)	(8.444)	(25.46)	(88.22)
Active Mines (t-1)	5.954	-10.81	-4.855	3.627
	(35.37)	(9.848)	(25.96)	(71.04)
Active Mines (t-2)	-26.95	-16.02	-42.97	48.69
	(31.95)	(10.33)	(26.05)	(60.87)
(log) Real GDP_t	1,939.9*	-659.7**	1,280.2.	8,575.3***
	(679.6)	(209.3)	(633.7)	(2,153.9)
(log) $Population_t$	62,741.2***	1,230.3	63,971.5***	
	(6,328.0)	(1,867.3)	(5,602.1)	
Fixed-effects				
County FIPS Code	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	55,296	55,296	55,296	55,296
R^2	0.99619	0.89335	0.99714	0.99684
Within R^2	0.10605	0.00097	0.12340	0.00619

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S27: Impact of the number of active mines on county employment indicators (log levels excl. UER)
Using a TWFE OLS regression model with two time lags on all contiguous US counties

Dependent Variables:	Unemployment Rate	Employed Persons (log)	Unemployed Persons (log)	Labour Force (log)	Population (log)
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Active Mines	-0.0955***	0.0015*	-0.0103***	0.0004	0.0012
	(0.0205)	(0.0006)	(0.0020)	(0.0006)	(0.0007)
Active $Mines_{t-1}$	-0.0035	0.0012.	-9.24×10^{-5}	0.0012	0.0003
	(0.0157)	(0.0007)	(0.0015)	(0.0007)	(0.0007)
Active $Mines_{t-2}$	0.0619***	-0.0005	0.0040*	0.0002	0.0010
	(0.0122)	(0.0004)	(0.0015)	(0.0005)	(0.0007)
(log) Real $GDPPC_t$	-0.9989**				
	(0.2558)				
(log) Real GDP_t		0.1035***	-0.0926**	0.0929***	0.0665***
		(0.0106)	(0.0300)	(0.0099)	(0.0110)
(log) $Population_t$		0.9033***	1.103***	0.9189***	
		(0.0298)	(0.0878)	(0.0287)	
Fixed-effects					
County FIPS Code	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	55,296	55,296	55,296	55,296	55,296
R^2	0.84472	0.99857	0.99204	0.99876	0.99891
Within R^2	0.02664	0.45766	0.12865	0.49102	0.05022

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S28: Impact of a change in active mines on county employment indicators (log levels excl. unemployment rate)
Using a TWFE OLS regression model on all contiguous US counties

Dependent Variables:	Unemployment Rate	Employed Persons (log)	Unemployed Persons (log)	Labour Force (log)	Population (log)
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
Δ Active Mines$_{t}$	-0.0835***	0.0007	-0.0081***	-0.0002	0.0003
	(0.0198)	(0.0006)	(0.0020)	(0.0007)	(0.0008)
Δ Active Mines$_{t-1}$	-0.0884***	0.0020**	-0.0082***	0.0010.	0.0006
	(0.0148)	(0.0005)	(0.0020)	(0.0005)	(0.0008)
Δ Active Mines$_{t-2}$	-0.0446**	0.0021***	-0.0044.	0.0016***	0.0009
	(0.0149)	(0.0005)	(0.0021)	(0.0004)	(0.0007)
(log) Real GDPPC$_{t}$	-1.011***				
	(0.2531)				
(log) Real GDP$_{t}$		0.1044***	-0.0955**	0.0937***	0.0679***
		(0.0105)	(0.0294)	(0.0098)	(0.0112)
(log) Population$_{t}$		0.9051***	1.097***	0.9203***	
		(0.0302)	(0.0887)	(0.0290)	
Fixed-effects					
County FIPS Code	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	55,296	55,296	55,296	55,296	55,296
R^2	0.84465	0.99857	0.99203	0.99876	0.99891
Within R^2	0.02622	0.45720	0.12733	0.49067	0.04813

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

E.2 First-difference indicators

Table S29: Impact of change in active mines on the change in unemployment rate
Using a TWFE OLS regression model on all contiguous counties and coal counties with various combinations of time lags and leads

Dependent Variable:	Δ Unemployment Rate					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
	All US Counties			Coal Counties Only		
Variables						
Δ Active Mines_{t+3}			-0.0186*			-0.0087
			(0.0082)			(0.0080)
Δ Active Mines_{t+2}		-0.0050	-0.0056		-0.0068	-0.0065
		(0.0112)	(0.0128)		(0.0084)	(0.0097)
Δ Active Mines_{t+1}		-0.0203	-0.0168		-0.0201	-0.0169
		(0.0206)	(0.0184)		(0.0182)	(0.0170)
Δ Active Mines_{t}	-0.0562**	-0.0588***	-0.0587***	-0.0410**	-0.0441**	-0.0427**
	(0.0142)	(0.0142)	(0.0138)	(0.0124)	(0.0127)	(0.0127)
Δ Active Mines_{t-1}	-0.0070	-0.0083	-0.0138	-0.0040	-0.0062	-0.0094
	(0.0138)	(0.0158)	(0.0160)	(0.0100)	(0.0118)	(0.0124)
Δ Active Mines_{t-2}	0.0391**	0.0388*	0.0274.	0.0343**	0.0333**	0.0264*
	(0.0131)	(0.0137)	(0.0139)	(0.0106)	(0.0111)	(0.0123)
Δ Active Mines_{t-3}	0.0013		-0.0078	0.0036		-0.0026
	(0.0104)		(0.0099)	(0.0074)		(0.0078)
Δ (log) Real GDPPC_{t}	-0.9738***	-0.9937***	-1.025***	-1.587***	-1.611***	-1.647***
	(0.2137)	(0.2181)	(0.2177)	(0.3505)	(0.3667)	(0.3715)
Fixed-effects						
County FIPS Code	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	55,295	49,151	46,079	4,518	4,016	3,765
R^2	0.61338	0.61965	0.62238	0.65489	0.66562	0.67289
Within R^2	0.01470	0.01532	0.01530	0.04548	0.05083	0.04918

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

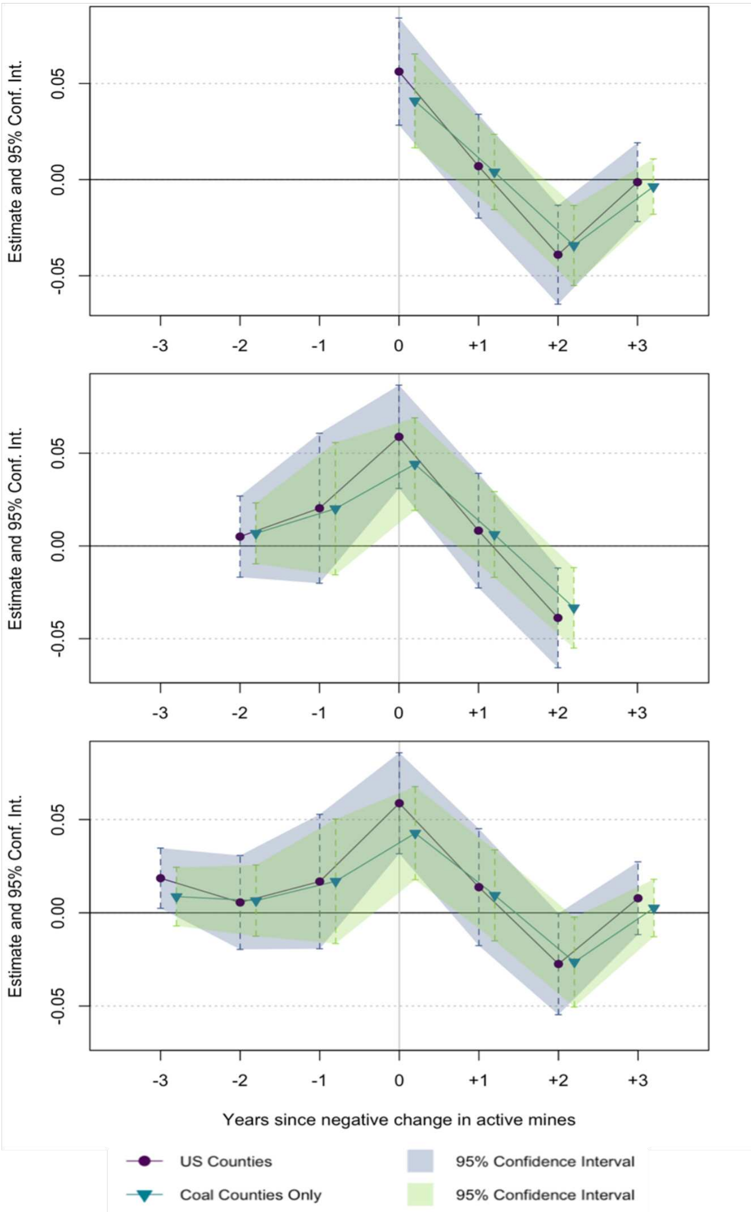


Figure S5: *Figure 1 illustrates the sequence of responses in county unemployment rate to a change in active mines at time t = 0 and associated 95% confidence intervals with three leads and three lags. For simplified interpretation, the sign of the impact has been flipped to illustrate the change in unemployment rate resulting from a decrease in active mines. The y-axis indicates the time since the change in active mines was reported. Exact coefficients are reported in Tables S29. Exact coefficients are reported in S8 and S9 of the Supplementary Materials.*

Table S30: Impact of change in active mines in various time periods on the change in unemployment rate
Using a TWFE OLS regression model on all contiguous counties and coal counties using single time periods

Dependent Variable:	Δ Unemployment Rate							
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables								
Δ Active Mines_{t}	-0.0560**				-0.0416**			
	(0.0151)				(0.0127)			
Δ Active $\text{Mines}_{t\text{-}1}$		-0.0050				-0.0029		
		(0.0137)				(0.0096)		
Δ Active $\text{Mines}_{t\text{-}2}$			0.0402*				0.0351**	
			(0.0151)				(0.0116)	
Δ Active $\text{Mines}_{t\text{-}3}$				0.0011				0.0026
				(0.0136)				(0.0098)
Δ (log)Real GDPPC_{t}	-0.9742***	-0.9837***	-0.9846***	-0.9842***	-1.596***	-1.699***	-1.701***	-1.702***
	(0.2137)	(0.2137)	(0.2138)	(0.2136)	(0.3513)	(0.3482)	(0.3416)	(0.3469)
Fixed-effects								
County FIPS Code	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics								
Observations	55,295	55,295	55,295	55,295	4,518	4,518	4,518	4,518
R^2	0.61298	0.61227	0.61267	0.61226	0.65184	0.64795	0.65105	0.64794
Within R^2	0.01367	0.01186	0.01288	0.01185	0.03705	0.02628	0.03487	0.02627

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Three additional factors are likely to confound the estimation of the effect reported in the main text: different levels of labour productivity between surface and underground mines, heterogeneity in mine size, and heterogeneity in a county's share of employment in coal mining. We are able to tackle the first of these issues directly using our existing data. However, adequately addressing the latter two factors is severely limited by data availability. Nevertheless, we outline our best efforts to address all three confounding factors. All results except one reported below support the headline results reported in the main text. The exception represents the estimation that suffers from the greatest source of data uncertainty.

E.3 Underground versus Surface Coal Mines

First, we divide the coal mines in the dataset used in our main analysis by whether a mine was an underground or surface mine.

Table S31: Impact of change in active surface mines on change in unemployment rate

	ΔUnemployment Rate				
	TWFE OLS	SLX	SARAR		
			Direct	Indirect	Total
Spatial Error Parameter		0.742***			
		(0.004)			
ΔActive Surface Mines$_{i,t}$	-0.055*	-0.033***	-0.036***	-0.219***	-0.255***
	(0.019)	(0.008)	0.008	0.046	0.053
ΔActive Surface Mines$_{i,t-1}$	-0.014	-0.016*	-0.016.	-0.097.	-0.113.
	(0.024)	(0.008)	0.008	0.048	0.056
ΔActive Surface Mines$_{i,t-2}$	0.044.	0.021*	0.028***	0.167***	0.195***
	(0.023)	(0.008)	0.008	0.049	0.057
Δ(log) Real GDPPC	-0.98***	-0.545***	-0.554***	-3.344***	-3.898***
	(0.214)	(0.03)	0.033	0.225	0.256
ΔActive Surface Mines$_{-i,t}$		-0.079***			
		(0.021)			
ΔActive Surface Mines$_{-i,t-1}$		0.014			
		(0.022)			
ΔActive Surface Mines$_{-i,t-2}$		0.046*			
		(0.022)			

Table S32: Impact of change in active underground mines on change in unemployment rate

	ΔUnemployment Rate				
	TWFE OLS	SLX	SARAR		
			Direct	Indirect	Total
Spatial Error Parameter		0.741***			
		(0.004)			
ΔActive Underground Mines$_{i,t}$	-0.128***	-0.082***	-0.089***	-0.539***	-0.628***
	(0.032)	(0.009)	0.009	0.057	0.066
ΔActive Underground Mines$_{i,t-1}$	-0.007	-0.006	-0.003	-0.017	-0.02
	(0.025)	(0.01)	0.009	0.056	0.065
ΔActive Underground Mines$_{i,t-2}$	0.053*	0.044***	0.047***	0.286***	0.333***
	(0.024)	(0.01)	0.009	0.053	0.061
Δ(log) Real GDPPC	-0.975***	-0.544***	-0.55***	-3.316***	-3.866***
	(0.213)	(0.03)	0.03	0.205	0.234
ΔActive Underground Mines$_{-i,t}$		-0.135***			
		(0.026)			
ΔActive Underground Mines$_{-i,t-1}$		-0.012			
		(0.026)			
ΔActive Underground Mines$_{-i,t-2}$		0.052*			
		(0.026)			

E.4 Heterogeneity in Mine Size

In order to address the legitimate concern that heterogeneity in mine size might impact the results presented in the main text of this work we performed two key robustness checks. Ideally, a satisfactory robustness check would assess the impact of changes in county-level coal productive capacity on county-level unemployment rate. However, this data is only available at the state level. Therefore, under these data constraints, we report below the results of two alternative robustness checks and their respective limitations.

First, using data from the US Energy Information Administration on county-level coal production (in million short tons), we assess the impact of changes in county-level production on county unemployment rate through TWFE OLS, SLX, and SARAR models whose functional forms are reported in Table 1. The limitation of using production as a legitimate proxy for changes in capacity is that it is subject to fluctuations resulting (mainly) from forces other than mine closures. Nevertheless, the results of this first model confirm the sign and statistical significance of the effects we report in the main text. Results are reported in Table S33.

Second, using data on *state-level* productive capacity and county-level mine closures we extrapolate changes in county-level productive capacity by interacting negative (positive) state-level changes in productive capacity (in million short tons) with the share of annual coal production in counties that experienced mine closures (openings). This interaction allows us to extrapolate a panel of county-level variation in productive capacity by assuming that capacity reduction (expansions) in counties that experienced mine closures (openings) is proportional to their share of state-level production. We acknowledge and emphasize the severe limitations of this assumption but nonetheless report the results below which replicate the sign of the results of our spatial econometric models reported in the main text albeit with relatively low statistical significance. Practically, we assess the impact of changes in county-level productive capacity on county-level unemployment rate again using TWFE OLS, SLX, and SARAR models whose functional forms are reported in Table 1. Results are reported in Table S34.

In summary, these two attempts to control for the size of a mine closed using county-level production volumes as well as a measure of county-level productive capacity backed out from state-level productive capacity figures and county-level shares of state-level production provide considerable confidence in our headline results. Construction of the latter metric relies on a much broader set of assumptions than the former which likely explains the less statistically significant results reported in Table S33. Regardless, the results of the spatial specifications using this latter data align in sign with our headline specification indicating the likely robustness of our headline results as reported in the main text.

Table S33: Impact of change in production (million short tons) on change in unemployment rate

	ΔUnemployment Rate				
	TWFE OLS	SLX	SARAR		
			Direct	Indirect	Total
$\Delta Production_{i,t}$	-0.045**	-0.039***	-0.043***	-0.258***	-0.301***
	(0.014)	(0.006)	0.006	0.037	0.043
$\Delta Production_{i,t-1}$	-0.001	0.005	0.005	0.031	0.036
	(0.008)	(0.006)	0.006	0.035	0.041
$\Delta Production_{i,t-2}$	0.013	0.018**	0.019**	0.113**	0.132**
	(0.008)	(0.006)	0.006	0.036	0.042
Δ(log) Real GDPPC	-0.976***	-0.544***	-0.551***	-3.335***	-3.886***
	(0.214)	(0.03)	0.027	0.186	0.212
$\Delta Production_{-i,t}$		-0.08***			
		(0.017)			
$\Delta Production_{-i,t-1}$		0.066***			
		(0.017)			
$\Delta Production_{-i,t-2}$		0.013			
		(0.017)			

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S34: Impact of change in production (million short tons) on change in unemployment rate

	ΔUnemployment Rate				
	TWFE OLS	SLX	SARAR		
			Direct	Indirect	Total
$\Delta Capacity^*_{i,t}$	0.016	-0.005	-0.006	-0.033	-0.039
	(0.013)	(0.015)	0.015	0.09	0.104
$\Delta Capacity^*_{i,t-1}$	-0.023	-0.02	-0.021	-0.129	-0.15
	(0.016)	(0.015)	0.016	0.096	0.112
$\Delta Capacity^*_{i,t-2}$	0.018***	0.022	0.023	0.142	0.165
	(0.001)	(0.015)	0.016	0.094	0.109
Δ(log) Real GDPPC	-0.984***	-0.548***	-0.557***	-3.372***	-3.93***
	(0.214)	(0.03)	0.031	0.204	0.233
$\Delta Capacity^*_{-i,t}$		-0.055			
		(0.045)			
$\Delta Capacity^*_{-i,t-1}$		0.014			
		(0.045)			
$\Delta Capacity^*_{-i,t-2}$		0.03			
		(0.045)			

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

E.5 Heterogeneity in Share of County-level Employment in Coal Mining

The effect of a change in the number of active mines in a particular county will depend on the share of county-level employment in coal mining. Adequately controlling for this heterogeneity in county-level employment in the coal industry is limited by a lack of data availability. County-level industrial employment data is available from two sources: U.S. Census Bureau's County Business Patterns (CBP) database and the U.S. Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW). Both data sources are subject to regulation by the Federel Committee on Statistical

Methodology which aims to ensure the "application of statistical disclosure limitation procedures whose purpose is to ensure that the risk of disclosing confidential information about identifiable persons, businesses or other units will be very small." In accordance with this objective, the US Census Bureau and BLS have procedures in place to ensure that employment numbers published cannot be attributed to individual persons or firms. As such, both data sources suffer from data missingness when it comes to local-level employment numbers, particularly in smaller, more rural jurisdictions. TThis bias towards non-disclosure in smaller, more rural jurisdictions means that our analysis would be especially limited as coal mining is generally concentrated in such areas. Our initial decision to focus our main results on overall or aggregate employment statistics (unemployment rate, employment, etc.) was partly motivated by this limitation.

In light of these data limitations, we present two new estimation attempts here using three different measures of county-level employment share in coal mining drawn from the aforementioned QCEW data which provides sector-level employment numbers categorised by the North American Industry Classification System Codes (NAICS). We chose to employ the QCEW data over the CBP as it provided a more complete picture of sector-level employment at the county level in the counties that engage in coal mining. First, (1) we use the raw data available on county-level employment shares as reported in QCEW calculated as the ratio of the number of persons employed in the coal sector (sum of persons employed in NAICS 2121 "Coal mining" and NAICS 213113 "Support activities for coal mining") over the total number of persons employed in all sectors (NAICS 10). Years in which a county's employment share is missing we calculate the labour intensity of mines in years in which employment is reported (employment in coal mining divided by the total number of active mines in a given year) and either (2) linearly impute the labour intensity within a county in years in which the employment number is missing or (3) calculate the county-level mean labour intensity to fill in missing values. Finally, in the case of (2) and (3) we multiply the relevant labour intensity measure by the number of active mines in a county and divide by the level of employment in all industries to arrive at a county-level employment share in mining. Ideally, this county-specific interpolation of missing data will keep our estimates as loyal to county-specific production conditions as possible. Despite this effort to impute missing data, there are a few counties that remain without estimates of county-level employment shares in mining despite reporting the presence of active mines. In these cases, we fill missing values with the product of state-level labour intensity in mining in a given year and the number of active mines in a county and divide by county-level employment in all industries. We refer to (1) as "Raw Data", (2) as "Data w. Interpolated Labour Intensity", (3) "Data w. Mean Labour Intensity" in Tables S35.

In terms of estimation strategy we present two below:

- We simply control for county-level employment share in coal mining as an additional regressor. This allows us to separate out the influence of mining employment share on unemployment rate. We find that controlling for county-level employment share in mining has a very minimal effect on our regression results as exemplified by comparing Models 2, 4, 6 in the below table with our main model result in column (1).
- In a second specification to control for share of employment in coal mining, we introduce a discrete interaction term that represents whether a county has a low (less than or equal to 10% of total employment), medium (greater than 10% and less than or equal to 20% of total employment), or high (greater than 20% of total employment) level of reliance on coal mining for employment. In this estimation, we find that, across all three data variations, that the contemporaneous effect of a coal mine closure on county-level employment is nearly double that reported in our main specification as well as in counties with a low level of employment share in mining (.10 percentage points versus 0.056 in our main estimation and 0.479 in counties with a low level of employment share in mining). When looking at the time dynamic, we find that the "recovery" as outlined in our main specification only manifests in counties with a low and medium shares of employment in coal. Whereas the evidence for such a recovery in counties with a high employment share in coal has a lower coefficient estimate as well as being statistically insignificant. Furthermore, what becomes evident in this additional analysis is that the magnitude of the contemporaneous unemployment rate response doubles in magnitude in counties with a high share of employment in coal mining indicating that there is heterogeneity in the contemporaneous response as well as the detected "recovery" two years following a mine closure, in line with the analysis reported in our main text in which we incorporate our County Types in a grouped

fixed effects estimation allowing for heterogeneous treatment effects. In order to assess the effects across different shares of employment in coal mining we provide linear combinations of the contemporaneous effects as well as lagged effects to demonstrate the heterogeneity in magnitude of the contemporaneous as well as persistence effects in Tables S36 and S37 below. Column (1) in each of these tables includes our main specification for reference. The effect of a coal mine closure increases in magnitude with an increasing share of employment in coal (as measured by our discrete indicator). Most notably, the contemporaneous effect of a single mine closure is nearly double for counties with a "high" share of employment in coal mining as compared to both our main specification and the detected effect in counties with a low level of employment share in mining (0.10 percentage points versus 0.056 in our main estimation and roughly 0.48 in counties with a low level of employment share in mining). When looking at the level of persistence of these effects (calculated as the linear combination of the regression coefficients on time-lagged treatment variables as well as the interaction of the discrete coal share indicator on these treatment variables), we find no statistically significant result of a persistent effect two years following a mine closure except in the case of counties with a high share of employment in coal mining, albeit at a below or near 10% level of statistical significance across our various datasets. This evidence is explained well by the regression results in Table S35, as the "recovery" as outlined in our main specification only manifests in counties with low and medium shares of employment in coal. The evidence for such a recovery in counties with a high employment share in coal has a lower coefficient estimate as well as being statistically insignificant.

Table S35: Regression Results Controlling for County-level Employment Share in Coal Mining

Dependent Variable:	Δ Unemployment Rate						
Data:	Main	Raw Data		Interp. Labour Intensity		Mean Labour Intensity	
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables							
Δ Active Mines$_{t}$	-0.0563***	-0.0563***	-0.0481***	-0.0571***	-0.0466***	-0.0576***	-0.0482***
	(0.0141)	(0.0141)	(0.0122)	(0.0143)	(0.0129)	(0.0144)	(0.0132)
Δ Active Mines$_{t-1}$	-0.0070	-0.0074	-0.0156	-0.0079	-0.0166	-0.0084	-0.0156
	(0.0136)	(0.0136)	(0.0125)	(0.0132)	(0.0124)	(0.0131)	(0.0131)
Δ Active Mines$_{t-2}$	0.0389***	0.0386***	0.0356***	0.0384***	0.0357**	0.0377***	0.0333**
	(0.0125)	(0.0123)	(0.0115)	(0.0122)	(0.0124)	(0.0118)	(0.0120)
Change in (log) Real GDPPC	-0.9738***	-0.9732***	-0.9721***	-0.9734***	-0.9719***	-0.9733***	-0.9723***
	(0.2137)	(0.2138)	(0.2142)	(0.2137)	(0.2140)	(0.2138)	(0.2141)
Coal Employment Share		1.209		0.7205		0.9066	
		(0.7523)		(0.6329)		(0.8251)	
Coal Employment Share (medium)			0.1460		0.0459		0.0969
			(0.1317)		(0.1038)		(0.1300)
Coal Employment Share (high)			0.3092		0.1232		0.1309
			(0.2797)		(0.2063)		(0.2700)
Coal Employment Share (medium) × Δ Active Mines$_{t}$			-0.0358		-0.0255		-0.0166
			(0.0339)		(0.0348)		(0.0282)
Coal Employment Share (high) × Δ Active Mines$_{t}$			-0.0389**		-0.0604**		-0.0522***
			(0.0140)		(0.0240)		(0.0179)
Coal Employment Share (medium) × Δ Active Mines$_{t-1}$			0.0596*		0.0421**		0.0317
			(0.0326)		(0.0196)		(0.0259)
Coal Employment Share (high) × Δ Active Mines$_{t-1}$			-0.0040		0.0048		0.0046
			(0.0333)		(0.0303)		(0.0287)
Coal Employment Share (medium) × Δ Active Mines$_{t-2}$			0.0266		0.0141		0.0211
			(0.0274)		(0.0243)		(0.0219)
Coal Employment Share (high) × Δ Active Mines$_{t-2}$			-0.0208		-0.0164		-0.0143
			(0.0446)		(0.0284)		(0.0354)
Fixed-effects							
County FIPS Code	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics							
Observations	55,295	55,295	55,295	55,295	55,295	55,295	55,295
R^2	0.61338	0.61343	0.61364	0.61341	0.61356	0.61342	0.61352
Within R^2	0.01470	0.01483	0.01535	0.01476	0.01515	0.01479	0.01506

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table S36: Contemporaneous Effect of Change in Active Mines Controlling for Share of Employment in Coal

Dependent Variable:	Δ Unemployment Rate						
Data:	Main	Raw Data		Interp. Labour Intensity		Mean Labour Intensity	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Low	-0.056***	-0.056***	-0.048***	-0.057***	-0.047***	-0.058***	-0.048***
	(0.014)	(0.014)	(0.012)	(0.014)	(0.013)	(0.014)	(0.013)
	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Medium			-0.084*		-0.072*		-0.065*
			(0.038)		(0.036)		(0.029)
			(0.028)		(0.046)		(0.025)
High			-0.087***		-0.107***		-0.100***
			(0.015)		(0.023)		(0.018)
			(<0.001)		(<0.001)		(<0.001)

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Table S37: Persistent Effect of Change in Active Mines Controlling for Share of Employment in Coal

Dependent Variable:	Δ Unemployment Rate						
Data:	Main	Raw Data		Interp. Labour Intensity		Mean Labour Intensity	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Low	-0.024	-0.025	-0.028	-0.027	-0.028	-0.028	-0.031
	(0.027)	(0.027)	(0.025)	(0.026)	(0.027)	(0.026)	(0.027)
	(0.364)	(0.346)	(0.269)	(0.307)	(0.307)	(0.273)	(0.251)
Medium			0.002		-0.016		-0.012
			(0.061)		(0.054)		(0.055)
			(0.970)		(0.770)		(0.827)
High			-0.092		-0.099+		-0.092
			(0.064)		(0.057)		(0.056)
			(0.150)		(0.082)		(0.102)

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

E.6 Controlling for Rurality

Table S38: Impact of change in active mines on change in unemployment rate
Using a TWFE OLS regression model and binary interaction term for whether a county is rural or not (Rural = 1; Non-rural = 0)

Dependent Variable:	Δ Unemployment Rate	
Model:	(1)	(2)
Variables		
Δ Active Mines$_t$	-0.0308*	-0.0119
	(0.0135)	(0.0134)
Δ Active Mines$_{t-1}$	-0.0371*	-0.0306.
	(0.0163)	(0.0160)
Δ Active Mines$_{t-2}$	0.0027	-0.0039
	(0.0144)	(0.0140)
Δ (log) Real GDPPC$_t$	-0.9736***	-1.583***
	(0.2137)	(0.3493)
Δ Active Mines × Rural	-0.0288	-0.0335
	(0.0218)	(0.0221)
Δ Active Mines$_{t-1}$ × Rural	0.0346	0.0301
	(0.0237)	(0.0238)
Δ Active Mines$_{t-2}$ × Rural	0.0420*	0.0435*
	(0.0152)	(0.0172)
Fixed-effects		
County FIPS Code	Yes	Yes
Year	Yes	Yes
Fit statistics		
Observations	55,295	4,518
R^2	0.61349	0.65598
Within R^2	0.01496	0.04851

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

E.7 Effect of Change in Active Mines on Sector-level Employment

Table S39: Change in (log) Employment Levels

Dependent Variables:	Coal mining & coal and other mineral and ore merchant wholesalers	Coal mining, sales & fossil fuel electric power generation	Coal mining & support activities	Total employment excluding mining and coal sales
Model:	(1)	(2)	(3)	(4)
Variables				
Δ Active Mines_{t}	0.0032***	0.0033***	0.0032***	0.0010***
	(0.0008)	(0.0008)	(0.0007)	(0.0003)
Δ Active Mines_{t-1}	0.0028	0.0027	0.0027	0.0010***
	(0.0017)	(0.0017)	(0.0017)	(0.0003)
Δ Active Mines_{t-2}	0.0005	0.0004	0.0005	0.0005
	(0.0014)	(0.0014)	(0.0014)	(0.0004)
Change in Population (log)	-0.0010	0.0018	-0.0008	0.3612***
	(0.0092)	(0.0106)	(0.0092)	(0.0529)
Change in Real GDP (log)	0.0020	0.0025	0.0020	0.0652***
	(0.0013)	(0.0016)	(0.0013)	(0.0080)
Fixed-effects				
County FIPS Code	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	55,295	55,295	55,295	55,295
R^2	0.01179	0.01188	0.01169	0.24981
Within R^2	0.00505	0.00405	0.00498	0.05530

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table S40: Change in (log) Employment Levels (Secondary Sectors)

Dependent Variables:	NAICS 10 All industries	NAICS 23 Construction	NAICS 72 Accommodation and food services	NAICS 21 Mining, quarrying, and oil and gas extraction	NAICS 55 Management of companies and enterprises	NAICS 61 Educational services
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Δ Active Mines_{t}	0.0016***	0.0014	-1×10^{-5}	0.0038***	-0.0001	-0.0007
	(0.0004)	(0.0008)	(0.0008)	(0.0006)	(0.0003)	(0.0009)
Δ Active $\text{Mines}_{\text{t-1}}$	0.0013***	0.0011**	0.0003	0.0013	0.0003	-0.0016*
	(0.0003)	(0.0004)	(0.0006)	(0.0020)	(0.0003)	(0.0008)
Δ Active $\text{Mines}_{\text{t-2}}$	0.0005*	2.67×10^{-5}	0.0016***	-0.0024	0.0005*	-0.0004
	(0.0003)	(0.0005)	(0.0004)	(0.0016)	(0.0003)	(0.0008)
Change in Population (log)	0.3620***	0.3004***	0.1970***	0.1465**	0.0356**	0.1177**
	(0.0535)	(0.0708)	(0.0420)	(0.0635)	(0.0139)	(0.0484)
Change in Real GDP (log)	0.0656***	0.0607***	0.0169***	0.0327***	0.0030*	-0.0012
	(0.0080)	(0.0108)	(0.0038)	(0.0082)	(0.0016)	(0.0034)
Fixed-effects						
County FIPS Code	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	55,295	55,295	55,295	55,295	55,295	55,295
R^2	0.25640	0.06033	0.02495	0.03795	0.05300	0.02508
Within R^2	0.05860	0.00598	0.00102	0.00603	0.00013	0.00011

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table S41: Change in (log) Employment Levels

Dependent Variables:	Coal mining & coal and other mineral and ore merchant wholesalers	Coal mining, sales & fossil fuel electric power generation	Coal mining & support activities	Total employment excluding mining and coal sales
Model:	(1)	(2)	(3)	(4)
Variables				
Δ Active Mines$_t$ × Coal Employment Share = 1-low	0.0218	0.0236	0.0209	0.0012**
	(0.0193)	(0.0198)	(0.0195)	(0.0005)
Δ Active Mines$_t$ × Coal Employment Share = 2-medium	0.0155	0.0160	0.0314*	-0.0002
	(0.0246)	(0.0244)	(0.0175)	(0.0003)
Δ Active Mines$_t$ × Coal Employment Share = 3-high	-0.0573	-0.0572	-0.0578	0.0027
	(0.0441)	(0.0441)	(0.0440)	(0.0027)
Δ Active Mines$_{t-1}$ × Coal Employment Share = 1-low	0.0248	0.0244	0.0244	0.0008*
	(0.0197)	(0.0197)	(0.0201)	(0.0004)
Δ Active Mines$_{t-1}$ × Coal Employment Share = 2-medium	0.0106	0.0096	-0.0098**	0.0022***
	(0.0165)	(0.0169)	(0.0043)	(0.0007)
Δ Active Mines$_{t-1}$ × Coal Employment Share = 3-high	0.0125	0.0126	0.0127	0.0010
	(0.0811)	(0.0811)	(0.0812)	(0.0026)
Δ Active Mines$_{t-2}$ × Coal Employment Share = 1-low	-0.0068	-0.0075	-0.0050	0.0004
	(0.0140)	(0.0140)	(0.0141)	(0.0004)
Δ Active Mines$_{t-2}$ × Coal Employment Share = 2-medium	0.0111	0.0112	0.0148	0.0015
	(0.0283)	(0.0282)	(0.0286)	(0.0012)
Δ Active Mines$_{t-2}$ × Coal Employment Share = 3-high	0.0141	0.0136	0.0140	0.0010
	(0.0432)	(0.0432)	(0.0430)	(0.0027)
Change in Population (log)	-0.0680	-0.1097	-0.0575	0.1945
	(0.0721)	(0.1190)	(0.0857)	(0.2882)
Change in Real GDP (log)	0.0112	0.0195	0.0114	0.0880***
	(0.0104)	(0.0200)	(0.0115)	(0.0098)
Fixed-effects				
County FIPS Code	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	55,295	55,295	55,295	55,295
R^2	0.01100	0.01092	0.01074	0.11421
Within R^2	0.00218	0.00144	0.00257	0.01970

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table S42: Change in (log) Employment Levels (Secondary Sectors)

Dependent Variables:	NAICS 10 All industries	NAICS 54 Professional, scientific, and technical services	NAICS 61 Educational services	NAICS 62 Health care and social assistance	NAICS 71 Arts, entertainment, and recreation	NAICS 72 Accommodation and food services
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Δ Active Mines$_t \times$ Coal Employment Share = 1-low	0.0014***	-0.0079	-0.0047	0.0096	0.0020	-0.0031
	(0.0004)	(0.0104)	(0.0074)	(0.0136)	(0.0052)	(0.0102)
Δ Active Mines$_t \times$ Coal Employment Share = 2-medium	0.0029***	0.0028	0.0069	0.0428	-0.0264	-0.0315
	(0.0006)	(0.0175)	(0.0262)	(0.0329)	(0.0195)	(0.0336)
Δ Active Mines$_t \times$ Coal Employment Share = 3-high	0.0021	-0.0489*	-0.0665	-0.0653	0.0293	0.0726
	(0.0020)	(0.0272)	(0.0612)	(0.0869)	(0.0233)	(0.0430)
Δ Active Mines$_{t\text{-}1} \times$ Coal Employment Share = 1-low	0.0013***	-0.0020	-0.0055	-0.0168	-0.0009	-0.0064*
	(0.0003)	(0.0106)	(0.0095)	(0.0107)	(0.0039)	(0.0036)
Δ Active Mines$_{t\text{-}1} \times$ Coal Employment Share = 2-medium	0.0020***	-0.0048	-0.0620	-0.0542	-0.0103	-0.0158
	(0.0004)	(0.0106)	(0.0374)	(0.0414)	(0.0164)	(0.0416)
Δ Active Mines$_{t\text{-}1} \times$ Coal Employment Share = 3-high	0.0024*	-0.0179	0.0228	0.1077	0.0347**	0.0554**
	(0.0012)	(0.0147)	(0.0517)	(0.0726)	(0.0123)	(0.0209)
Δ Active Mines$_{t\text{-}2} \times$ Coal Employment Share = 1-low	0.0004	0.0061	0.0060	-0.0075	0.0086	0.0210
	(0.0003)	(0.0124)	(0.0079)	(0.0147)	(0.0065)	(0.0122)
Δ Active Mines$_{t\text{-}2} \times$ Coal Employment Share = 2-medium	0.0015***	-0.0257	0.0038	-0.0805**	0.0053	0.0159
	(0.0002)	(0.0166)	(0.0254)	(0.0374)	(0.0192)	(0.0478)
Δ Active Mines$_{t\text{-}2} \times$ Coal Employment Share = 3-high	0.0014	-0.0148	-0.0570**	-0.0007	-0.0238	-0.0570
	(0.0028)	(0.0157)	(0.0245)	(0.0374)	(0.0221)	(0.0500)
Change in Population (log)	0.1954	0.4993	0.8147**	0.3883	0.7208***	1.153***
	(0.2885)	(0.4899)	(0.3683)	(0.5199)	(0.1938)	(0.2889)
Change in Real GDP (log)	0.0884***	-0.0208	-0.0161	-0.1041	0.0345	0.0566
	(0.0098)	(0.0726)	(0.0399)	(0.0955)	(0.0369)	(0.0693)
Fixed-effects						
County FIPS Code	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	55,295	55,295	55,295	55,295	55,295	55,295
R^2	0.11558	0.01008	0.01968	0.01214	0.01121	0.00955
Within R^2	0.02045	9.73×10^{-5}	0.00062	0.00058	0.00040	0.00038

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

E.8 Panel Error Correction Models

The models considered are primarily run using a first-difference methodology. This is done in order to pre-empt non-stationarity concerns, which are especially prevalent in trending macro-economic variables such as GDP per capita in the case of this study.

Using first differences allows for valid, unbiased estimation of regression coefficients, even if the variables are integrated to the degree of 1 i.e. they are I(1) as generally variables need to be I(0) for regression estimation to be valid. If a variable is integrated to the order 1, then taking the first difference will transform the data series to I(0).

However, when two (or more) I(1) series are co-integrated, estimation can still be valid in levels. In order to test whether to variables are co-integrated, we can use co-integration tests, such as the tests that Pedroni 1999 (18) proposes to use for panel data. In Table S43, we show the four relevant Pedroni Cointegration Tests for models with a TWFE set-up.

Results from these tests show that three out of four tests do not provide evidence for rejection of the null hypothesis of no co-integration, including the Parametric Panel t-statistic, which is essentially an ADF type test, that is frequently used in this context (see e.g. 16). We can only find support for co-integration using the panel ν-Statistic, which is a type of non-parametric variance ratio statistic.

For completeness and in order to account for the long-run dynamics, we therefore also include a Panel Error Correction Model that estimates the main model of this study in levels, see Table S44.

The Panel ECM results show that deviations from the equilibrium (Δuer) are adjusted back to equilibrium by about 25% each period. These results further show that mine closures are associated with a positive effect on the change in the unemployment rate contemporaneously ($\Delta ActiveMines$) as well as in the longer term ($ActiveMines_{t-1}$) but that this effect is attenuated in the second period ($ActiveMines_{t-2}$). This dynamic is entirely consistent with our main results in first differences.

Table S43: Tests for Cointegration for Fixed Effect Models

Test	Empirical Statistic	Standardised Statistic	p-value
Panel ν-statistic	211.21389	-63.529072	<0.001
Panel ρ-statistic	-190.91453	89.274072	1
Panel t-statistic (non-parametric)	-52.50747	140.571888	1
Panel t-statistic (parametric)	-174.43903	5.921003	1

[a] The null hypothesis is no cointegration. For detailed description of tests see Table 1 in Pedroni (1999).

Table S44: Panel Error Correction Model

Dependent Variable:	Δ Unemployment Rate
Model:	(1)
Variables	
UER_{t-1}	-0.2527***
	(0.0036)
Δ Active $Mines_t$	-0.0663***
	(0.0088)
Active $Mines_{t-1}$	-0.0250***
	(0.0070)
Active $Mines_{t-2}$	0.0316***
	(0.0067)
Δlog GDP_t	-1.050***
	(0.0654)
Fixed-effects	
County FIPS Code	Yes
Year	Yes
Fit statistics	
Observations	49,152
R^2	0.67080
Within R^2	0.13867

Clustered (County FIPS Code) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

E.9 Calculation of Total Employment Losses

In Table S45 below, we report the total employment losses on an annual basis and over the time period using our coefficient on a contemporaneous change in active mines from our main specification (as reported in Model 1 of Table S8 as well as the coefficients taken from our asymmetric estimation (as reported in Table S10) that distinguishes between the employment destruction and creation of an increase versus a decrease in the number of active mines in a county. We derive the following estimates by multiplying this coefficient by the total labour force in the county in which a mine closes (see equation below) and then summing across all counties (as demonstrated in Equation 2. We assume that the effect of each additional mine closure is additive and we also look at *net* closures per county (consistent with the treatment variables used throughout our analysis). Table S45 displays annual estimates of the employment losses and gains associated with coal mine closures, openings calculated, and the net effects of both.

$$\Delta UnemployedPersons = \sum_{i=1,t=1}^{N,T} \beta * LabourForce_{i,t} \tag{2}$$

Table S45: Annual and Total Employment Losses and Gains from Changes in Active Mines

		Δ Absolute # of Unemployed			Δ Absolute # of Unemployed (Asymmetric)		
Year	ΔActive Mines	Closures	Openings	Net	Closures	Openings	Net
2002	-223	4000	-1100	2900	5300	-400	5000
2003	20	1500	-1200	300	2000	-400	1600
2004	136	700	-4100	-3500	900	-1400	-500
2005	42	1800	-2100	-300	2400	-700	1600
2006	119	1100	-3200	-2100	1500	-1100	400
2007	-29	2000	-1400	600	2700	-500	2200
2008	127	1200	-3500	-2200	1700	-1200	500
2009	-159	3800	-500	3200	5100	-200	4900
2010	-12	2000	-2100	-100	2700	-700	2000
2011	49	1400	-2600	-1200	1900	-900	1000
2012	-135	4000	-1300	2700	5300	-400	4900
2013	-264	3900	-600	3300	5100	-200	4900
2014	-95	1800	-1000	700	2400	-400	2000
2015	-209	3500	-300	3100	4600	-100	4500
2016	-107	2100	-600	1400	2800	-200	2600
2017	-27	1500	-1200	400	2100	-400	1700
2018	-16	1700	-600	1100	2300	-200	2000
2019	-41	1200	-800	400	1600	-300	1300
Total	**-824**	**39100**	**-28400**	**10800**	**52200**	**-9700**	**42500**

The numbers reported should be interpreted as the change in the number of individuals unemployed.

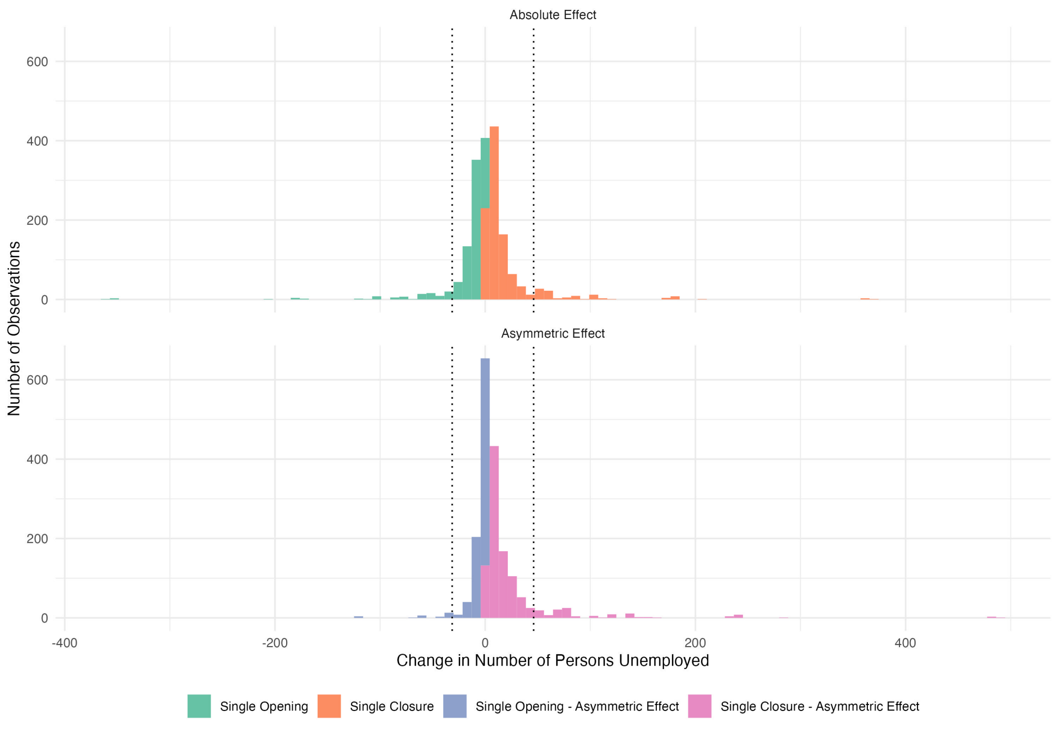


Figure S6: *Figure S6 displays a histogram of the predicted job losses associated with a single mine closure or opening as calculated using the coefficient estimates of our treatment variable (changes in the number of active mines) using Equation 4. The upper panel displays the predicted effect in the case where the estimate does not distinguish between closures and openings. The lower panel displays the predicted effect using the coefficient estimates calculated in our asymmetric treatment specification where we distinguish between closures and openings.*

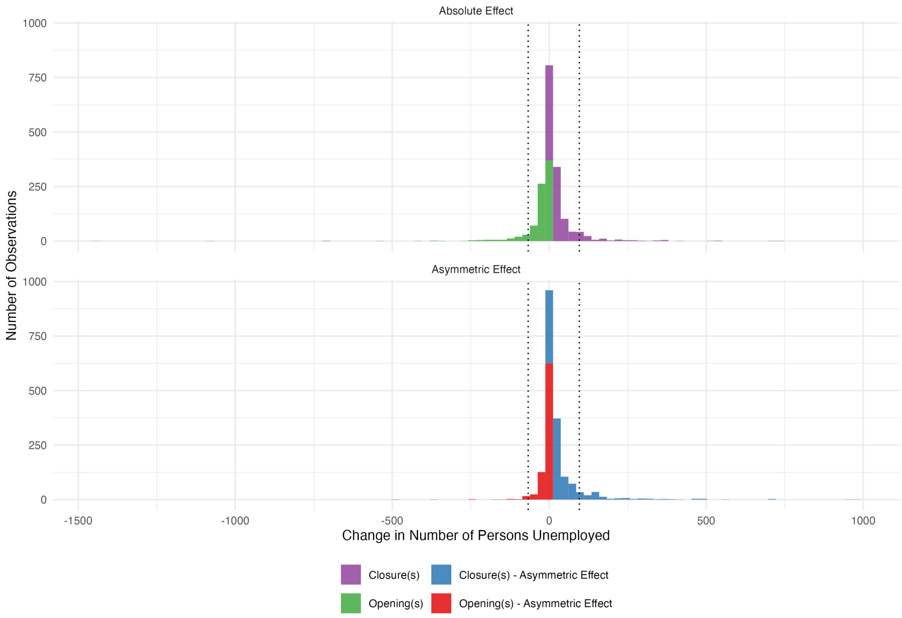


Figure S7: *Figure S7 displays a histogram of predicted job losses as calculated using the coefficient estimates of our treatment variable (changes in the number of active mines) using Equation 3. In this histogram, we display the predicted job losses associated with the real-world data on mine closures and openings. The values displayed in this histogram represent the product of predicted job losses on a county level per mine closed or opened with the actual number of mines closed or opened in a given year.*

Additionally, we provide a range of estimates of local-level job losses and gains resulting from mine closures and openings during the period of our dataset. As in the calculation above, we use both our headline estimate from Model 1 which does not distinguish between positive and negative changes in active mines in a county as well as the coefficient estimates from our asymmetric treatment estimation which does (and whose regression coefficients are reported in Table S10. In each of the tables below we report the predicted effect of observed levels of mine closures and openings in the dataset (see Equation 3) as well as the predicted effect of a single mine closure or opening on county-level unemployment levels (see Equation 4). The estimates are reported as the absolute value of the change in the number of unemployed individuals at a county-level. Therefore, and by construction, these values should be interpreted as an increase (decrease) in the number of individuals unemployed in the case of a closure (opening). Additionally, the N reported in the tables below represents the number of county-year observations for which negative or positive changes (of any magnitude) in the number of active mines were reported in our dataset.

$$\Delta UnemployedPersons_{i,t} = \beta * LabourForce_{i,t} * \Delta ActiveMines_{i,t} \tag{3}$$

$$\Delta UnemployedPersons_{i,t} = \beta * LabourForce_{i,t} \tag{4}$$

As reported in Tables S46 and S47 we find that mine closures are associated with a mean effect of 19 (25) jobs lost per single mine and 38 (50) jobs lost in a given year in which mine closures were reported as calculated using our main regression coefficient estimate (+0.056 percentage point increase in unemployment rate) (asymmetric treatment coefficient estimate +0.075 percentage point increase in unemployment rate). In contrast, mine openings are associated with a mean effect of 18 (6) jobs gained per single mine and 35 (12) jobs gained in a given year in which a net gain in active mines was reported as calculated using our main regression coefficient estimate (-0.056 percentage point decrease in unemployment rate) (asymmetric treatment coefficient estimate -0.019 percentage point decrease in unemployment rate). Over the time period covered in our dataset the range of jobs lost per single mine closure was [<1-367] ([1-490]) and the range of jobs lost in a given year in which a negative change in active mines was reported is [<1-734] ([1-981]). In the case of openings these ranges are [<1, 362] ([<1-124]) and [<1-1,444] ([<1, 495]), respectively.

Table S46: Detected Treatment Effects

Statistic	N	Mean	St. Dev.	Min	Max
Detected Effect of Closure(s)	1,039	38	68	<1	734
Detected Effect of Opening(s)	801	35	87	<1	1,444
Detected Effect of Single Closure	1,039	19	34	<1	367
Detected Effect of Single Opening	801	18	34	<1	362

Table S47: Detected Treatment Effects using Asymmetric Treatment Coefficients

Statistic	N	Mean	St. Dev.	Min	Max
Detected Effect of Closure(s)	1,039	50	90	1	981
Detected Effect of Opening(s)	801	12	30	<1	495
Detected Effect of Single Closure	1,039	25	46	1	490
Detected Effect of Single Opening	801	6	12	<1	124

E.10 Renewable Energy Investments: Evaluating the potential of the Inflation Reduction Act

In this supplementary analysis, we investigate whether county-level renewable energy investments as recorded by the USDA have had an alleviating effect on unemployment shocks resulting from changes in active mines by incorporating a binary interaction term representing whether renewable energy investments in a particular county exceeded 0.1% of $\mathrm{GDP}_{\mathrm{it}}$. The US Department of Agriculture maintains an energy investment database containing "information regarding USDA programs that provide assistance to renewable energy and efficiency projects" at state, county, and congressional district levels. For the purpose of this study, investments in renewable energy were retained and energy efficiency improvements were removed as they largely represented improvements in on-farm agricultural practices which were deemed unlikely to impact coal workers. The variable of interest derived from this data source is a binary indicator for whether county-level renewable energy investments exceed 0.1% of county real GDP in a particular year.

We find small and statistically insignificant alleviating impacts of renewable energy investments on unemployment rate changes caused by mine closures, while the other results remain robust. The econometric specification used to investigate this question is outlined in Equation 5. Furthermore, we run this specification using HTT(1) and HTT(2) to account for cross-sectional dependence issues. The general form of the HTT(d) model with d unknown factors is outlined in Equation 6 below and is identical to that denoted in 1. Regression coefficients for these specifications can be found in Tables S48 and S49 below.

We estimate both a standard TWFE OLS model as well as HTT(1) and HTT(2) models, as follows:

$$\Delta UER_{it} = \boldsymbol{\beta X}_{it} + \boldsymbol{Z}\begin{pmatrix} \Delta ActiveMines_{it} * REInvestments_{it} \\ \Delta ActiveMines_{it-1} * REInvestments_{it-1} \\ \Delta ActiveMines_{it-2} * REInvestments_{it-2} \end{pmatrix} + \alpha_i + \gamma_t + \varepsilon_{it} \tag{5}$$

$$\Delta UER_{it} = \boldsymbol{\beta X}_{it} + \sum_{l=1}^{d} \lambda_{il} f(t) + \alpha_i + \gamma_t + \varepsilon_{it} \tag{6}$$

Variable definitions:

$\boldsymbol{i}$: denotes each county for i=1, 2,... 3,072 counties

$\boldsymbol{t}$: denotes each year for t=2002, 2003,... 2019

$\boldsymbol{\alpha}_i$: unit-fixed effects

$\boldsymbol{\gamma}_t$: time-fixed effects

$\boldsymbol{X}_{it}$: Vector of independent variables (Δ Active Mines$_{\text{it}}$, Δ Active Mines$_{\text{it-1}}$, Δ Active Mines$_{\text{it-2}}$, RE Investments$_{\text{it}}$, RE Investments$_{\text{it-1}}$, RE Investments$_{\text{it-2}}$, log (Real GDPPC)$_{\text{it}}$).

log (Real GDPPC)$_{it}$: natural logarithm of county-level real GDP per capita.

$\boldsymbol{\beta}$: Vector of regression coefficients to be estimated.

$\boldsymbol{\lambda}_{il}$: Individual loadings parameter per unit i and factor l in heterogeneous trend models.

f(t): Unobserved time-varying common factors used in heterogeneous trend models.

d: Number of time-varying common factors used in heterogeneous trend models. In this estimation d takes the value of 1 and 2.

RE Investments$_{it}$: dummy indicator of whether renewable energy investments exceeded 0.1% of GDP$_{\text{it}}$.

$\boldsymbol{\Delta}UER_{it}$: Change in unemployment rate in county i in year t.

This latter analysis is excluded from the main text due to lack of statistical significance and concerns about the relative weakness of the data. However, we elected to include the analysis in the Supplementary Materials to demonstrate the results as well as provide evidence of the lack of adequate renewable energy investments made in the time period covered by our study. In other words, the statistically insignificant result is explained almost entirely by the fact that reported renewable energy investments in our dataset have not been made in coal counties, as defined in our study. More precisely, of the 55,296 observations in our study (3,072 counties across 18 years), we only observe 7,717 counties (14%) with renewable energy investments reported by the USDA. Of this subset, only 465 counties (0.8% of the total dataset and 6% of observations with non-zero values of renewable energy investment) had ever reported an active mine. In terms of magnitude, $6.3 trillion USD that have been invested in renewable energy projects tracked by the USDA during the time period analysed, only $122 million USD (2%) have been invested in coal counties, as defined in this study. In per capita terms, only 7.5 US$ per capita were allocated to coal counties while non-coal counties benefiting from investments received 25.1 US$ per capita. Therefore, the inability to detect such an impact at this stage is still of significance to the validity of the discourse that informs the policies outlined in the IRA; namely, that the green economy can sufficiently offset losses in brown industries. With the significant caveat that such investments will likely not provide sufficient relief, we nevertheless propose ramping up such investments to both decarbonise the US economy and enhance the potentialities of new employment in coal counties with already low economic diversification. In certain localities, such initiatives have been beneficial where favourable geography allows for profitable solar and wind farms (9). In other countries, in line with circular economy principles, coal mines have even been expressly repurposed for geothermal energy generation and renewable energy storage (3; 15). The Inflation Reduction Act is encouraging on that front, even though it ignores the likely utility of other complimentary policy measures.

Table S48: Regression Results: Impact of changes in active mines on unemployment rate accounting for county-level renewable energy investment

Dependent Variable:	Δ Unemployment Rate	
Model:	(1)	(2)
Variables		
Δ Active Mines$_t$	-0.0640**	-0.0470**
	(0.0163)	(0.0144)
Δ Active Mines$_{t-1}$	-0.0015	-0.0001
	(0.0160)	(0.0113)
Δ Active Mines$_{t-2}$	0.0434**	0.0369**
	(0.0135)	(0.0111)
Δ Active Mines$_t$ $\times$ REE$_t$	0.0606.	0.0562*
	(0.0286)	(0.0262)
Δ Active Mines$_{t-1}$ $\times$ REE$_{t-1}$	0.0150	0.0182
	(0.0180)	(0.0149)
Δ Active Mines$_{t-2}$ $\times$ REE$_{t-2}$	-0.0427*	-0.0335
	(0.0176)	(0.0272)
REE $\geq$ 0.1% of GDP$_t$	-0.0614*	-0.0015
	(0.0232)	(0.0408)
REE $\geq$ 0.1% of GDP$_{t-1}$	-0.0227	0.0192
	(0.0236)	(0.0494)
REE $\geq$ 0.1% of GDP$_{t-2}$	-0.0034	0.0765
	(0.0233)	(0.0661)
Δ (log) Real GDPPC$_t$	-1.009**	-1.617***
	(0.2519)	(0.3656)
Fixed-effects		
County FIPS Code	Yes	Yes
Year	Yes	Yes
Fit statistics		
Observations	49,152	4,016
R^2	0.62396	0.66401
Within R^2	0.01613	0.04872

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

Table S49: Regression Results: Impact of renewable energy investments on detected unemployment rate recovery following a change in active mines

Dependent Variable:	ΔUnemployment Rate			
Model:	(1)	(2)	(3)	(4)
Variables				
ΔActive Mines$_{t-2}$	0.0402*	0.0400*	0.0433*	0.0427*
	(0.0151)	(0.0161)	(0.0175)	(0.0178)
Δ Active Mines$_{t-2}$ $\times$ REE$_{t-1}$		0.0049		0.0229
		(0.0249)		(0.0300)
Δ Active Mines$_{t-2}$ $\times$ REE$_{t-2}$			-0.0440.	-0.0518*
			(0.0209)	(0.0204)
Δ (log) Real GDPPC$_t$	-0.9846***	-0.9986***	-1.021**	-1.021**
	(0.2138)	(0.2246)	(0.2519)	(0.2519)
Fixed-effects				
County FIPS Code	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	55,295	52,224	49,152	49,152
R^2	0.61267	0.61459	0.62292	0.62292
Within R^2	0.01288	0.01308	0.01340	0.01341

Clustered (County FIPS Code & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .:0.1*

Table S50: Coefficient estimates of 1-and 2- factor models incorporating Renewable Energy Investments

	(1)	(2)
	ΔUnemployment Rate	
Δ Active Mines$_t$	-0.069***	-0.069***
	(0.007)	(0.007)
Δ Active Mines$_{t-1}$	-0.007	-0.007
	(0.007)	(0.007)
Δ Active Mines$_{t-2}$	0.040***	0.040***
	(0.006)	(0.007)
REE $\geq$ 0.1% of GDP$_t$	-0.057***	-0.057***
	(0.013)	(0.014)
REE $\geq$ 0.1% of GDP$_{t-1}$	-0.016	-0.016
	(0.014)	(0.014)
REE $\geq$ 0.1% of GDP$_{t-2}$	0.007	0.007
	(0.015)	(0.015)
Δ Active Mines$_t$ $\times$ REE	0.073*	0.073*
	(0.029)	(0.030)
Δ Active Mines$_{t-1}$ $\times$ REE	0.030	0.030
	(0.032)	(0.033)
Δ Active Mines$_{t-2}$ $\times$ REE	-0.031	-0.031
	(0.031)	(0.032)
Δ (log) Real GDPPC$_t$	-0.962***	-0.962***
	(0.044)	(0.045)
R^2	0.434	0.434
Additive Effects Type	two-ways	two-ways
# Unobserved Factors Used	1	2

*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, .: 0.1*

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