The Safety Scapegoat: Mine Regulation, Market Forces, and the Decline of Coal Country

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Abstract

On January 2, 2006, an explosion at the Sago Mine in West Virginia killed 12 miners and triggered the MINER Act—the most sweeping federal mine safety legislation in three decades. We estimate the causal effect of this disaster-driven regulation on employment and earnings in 1,853 counties across 24 coal-producing states using a continuous-treatment difference-in-differences design. Counties with higher pre-reform mining employment shares experienced no employment decline in the five years following the MINER Act. A second shock—the 2010 Upper Big Branch explosion and subsequent enforcement crackdown—coincided with significant employment declines, but these declines were equally severe in Western states far from Appalachia, pointing to the natural gas revolution rather than regulatory enforcement as the primary driver. Safety regulation was not the job-killer its critics feared; market competition was.

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1. Introduction

Twelve miners walked into the Sago Mine on January 2, 2006. One walked out. The explosion that killed them dominated cable news for weeks, and within six months Congress passed the Mine Improvement and New Emergency Response Act (MINER Act)—the most significant overhaul of federal mine safety regulation since the Federal Mine Safety and Health Act of 1977. The law required every underground mine in America to install rescue chambers, deploy emergency communication systems, and maintain mine rescue teams, all within strict compliance deadlines. Four years later, an explosion at the Upper Big Branch mine killed 29 more miners, triggering an enforcement crackdown by the Mine Safety and Health Administration (MSHA). By 2015, coal employment had collapsed across Appalachia and the Mountain West, and regulation was a convenient culprit. But was it the right one?

This paper asks whether disaster-driven safety regulation causally reduced employment and earnings in U.S. coal mining counties. We exploit the sharp, unexpected timing of the MINER Act—enacted within five months of the Sago disaster by a Congress responding to media pressure, not to gradual economic trends—as a regulatory shock whose intensity varies continuously across counties based on pre-existing mining employment shares. Our design compares the trajectories of high-mining and low-mining counties within the same coal-producing states, before and after each regulatory shock.

Our findings on the first shock are clear: **we find no evidence that the MINER Act reduced employment in mining-intensive counties.** Point estimates are small, positive, and statistically insignificant across every specification we examine—continuous and binary treatment intensities, alternative base years, and subsamples excluding the most affected states. If anything, the MINER Act period saw mining county earnings rise, consistent with safety investments improving job quality—though compositional effects (e.g., layoffs of lower-wage workers) cannot be ruled out.

The post-2010 period tells a different story. Counties with higher mining shares experienced significant employment declines—a 34 percent reduction in log employment per unit of mining share ($p < 0.01$)—following the Upper Big Branch disaster and MSHA enforcement escalation. But a regional decomposition reveals that this decline was *equally severe* in Western coal states (Wyoming, Montana, Colorado) as in Appalachian states (West Virginia, Kentucky, Pennsylvania). Since UBB enforcement was concentrated in Appalachian underground mines, the Western symmetry is more consistent with the natural gas revolution—the contemporaneous collapse in coal's competitiveness as hydraulic fracturing drove natural gas prices to historic lows—than with regulatory enforcement as the primary cause. The evidence suggests that safety regulation was not the job-killer its critics feared.

Our contribution is threefold. First, we provide the first county-level estimates of the MINER Act's labor market effects. The only prior economic analysis of the MINER Act (Li, 2022) uses mine-level data and cannot recover the equilibrium effects—migration, wage spillovers, non-mining employment—that matter for communities. Second, we separate two competing narratives about coal's decline by exploiting the geographic distribution of regulatory enforcement versus market exposure. Third, we document that non-mining employment in mining counties shows no significant decline even after 2010, but hiring activity does—suggesting the coal contraction reduced labor market dynamism through a local multiplier channel (Moretti, 2010).

These findings speak to a broader literature on the employment costs of regulation. Walker (2013) estimates that Clean Air Act regulations cost roughly 15 percent of earnings for workers in newly regulated plants, with effects concentrated in transition costs rather than steady-state losses. Greenstone (2002) finds significant employment reductions from the Clean Air Act in pollution-intensive counties. Our continuous-treatment design follows the Bartik-style approach of Autor et al. (2013), who use pre-existing industry structure to measure exposure to a common shock. Our setting is distinctive because the regulatory shock was triggered not by environmental or public health concerns but by a salient disaster event, creating a natural experiment in media-driven policymaking (Eisensee and Strömberg, 2007). That the resulting regulation imposed no detectable employment cost—despite requiring expensive capital investments in every underground mine—suggests that disaster salience may generate regulations whose costs are smaller than critics anticipate, precisely because the salience itself signals genuine safety failures that the market had already been pricing (Boeri et al., 2021).

Our regional decomposition connects to the literature on place-based policy and local labor market decline (Kline and Moretti, 2014). The distinction between regulatory and market causes of coal decline has direct implications for transition policy: if regulation were the cause, deregulation could reverse the decline; if market competition were the cause, only adjustment assistance can help (Bartik, 1991).

The remainder of this paper proceeds as follows. Section 2 describes the MINER Act and Upper Big Branch enforcement. Section 3 presents the data. Section 4 details the identification strategy. Section 5 reports results. Section 6 presents robustness checks. Section 7 concludes.

2. Background

2.1 The Sago Mine Disaster and the MINER Act

The Sago Mine explosion on January 2, 2006 killed 12 of 13 trapped miners in Upshur County, West Virginia. The disaster received sustained national media coverage—the narrative of families waiting for news, the initial false report of survivors, and the final confirmation of deaths played out on live television over 41 hours. Congressional hearings began within weeks.

On June 15, 2006, President Bush signed the Mine Improvement and New Emergency Response Act (P.L. 109-236). The law imposed four categories of requirements on underground mines: (1) emergency response plans, reviewed and approved by MSHA; (2) emergency communication and tracking systems for all underground personnel; (3) mine rescue teams available within one hour; and (4) supplemental oxygen supplies and rescue chambers ("refuge alternatives") at designated locations. Compliance deadlines ranged from 60 days to three years, with the most expensive requirements—refuge alternatives and communication systems—due by June 2009.

The critical feature for identification is timing: the Sago disaster was sudden and unexpected, the legislative response was rapid (five months from disaster to signature), and the law was nationally uniform but differentially binding (Mine Safety and Health Administration, 2011). Counties where mining constituted a large share of employment faced proportionally larger compliance burdens, while counties with no mines were completely unaffected.

2.2 Upper Big Branch and Enforcement Escalation

On April 5, 2010, an explosion at the Upper Big Branch mine in Raleigh County, West Virginia killed 29 miners—the deadliest U.S. mine disaster since 1970. The mine was operated by Massey Energy, which had accumulated hundreds of safety violations. Unlike the Sago response, which focused on compliance mandates, the UBB aftermath focused on enforcement: MSHA launched intensive inspection campaigns, the Mine Safety and Health Review Commission increased penalty assessments, and Congress held hearings on the adequacy of existing enforcement mechanisms.

This enforcement crackdown occurred simultaneously with the shale gas revolution. U.S. natural gas production increased from 21.6 trillion cubic feet in 2009 to 24.1 trillion in 2012, driven by horizontal drilling and hydraulic fracturing in the Marcellus and Haynesville shales (Hausman and Kellogg, 2015). The Henry Hub natural gas price fell from $8.86/MMBtu in June 2008 to $2.75 in April 2012, making natural gas cheaper than coal for electricity generation in many regions. Coal's share of U.S. electricity generation fell from 48.2 percent in 2008 to 37.4 percent in 2012 (U.S. Energy Information Administration, 2023).

3. Data

Our analysis uses the Census Bureau's Quarterly Workforce Indicators (QWI), which provide county-level employment, earnings, hiring, separations, and firm-level job flows by industry at the 3-digit NAICS level. We focus on NAICS 212 (Mining, except Oil and Gas), which includes coal mining, metal ore mining, and nonmetallic mineral mining. An important limitation is that QWI does not separate coal from non-coal mining at the county level. In the coal-producing states that form our sample, coal mining dominates NAICS 212 employment, but some treatment variation may reflect non-coal mining activity. This measurement limitation attenuates our estimates toward zero, making our null finding on the MINER Act conservative but introducing noise into the post-2010 estimates.

We assemble a county-quarter panel covering 2000Q1 through 2016Q4 across 24 coal-producing states, yielding 124,380 county-quarter observations for 1,853 counties. The key outcome variables are: total employment (all industries), mining employment (NAICS 212), non-mining employment (residual), quarterly earnings per worker, all-hire counts, separation counts, and firm-level job gains and losses. All employment and earnings variables are logged in analysis.

Our treatment measure is the *mining employment share*: the 2005 annual average ratio of NAICS 212 employment to total employment in each county, measured one year before the MINER Act. This ranges from zero (1,291 counties with no mining employment) to 0.49 (the most mining-dependent county). Among the 562 counties with positive mining employment, the mean share is 0.036 and the median is 0.004, reflecting the highly skewed distribution of mining activity.

Table 1 presents summary statistics for the pre-MINER Act period, stratified by mining intensity. High-mining counties (share $> 5\%$) are smaller on average but have substantially higher earnings, reflecting the mining wage premium. These 70 counties, concentrated in Appalachia and the Mountain West, form the core of our treatment variation.

4. Empirical Strategy

We estimate a continuous-treatment difference-in-differences specification:

$$Y_{ct} = \alpha_c + \gamma_t + \beta_1 \left(\text{MiningShare}_c \times \text{Post}_t^{\text{MINER}}\right) + \beta_2 \left(\text{MiningShare}_c \times \text{Post}_t^{\text{UBB}}\right) + \varepsilon_{ct} \quad (1)$$

Table 1: Summary Statistics: Pre-MINER Act Period (2000Q1–2006Q2)

	High Mining (>5%)	Low Mining (0–5%)	No Mining (0%)
Counties	70	492	1291
Total employment (mean)	6230	208269	13270
Total employment (sd)	(5767)	(750194)	(36426)
Quarterly earnings ($)	2612	2616	2296
Mining share (mean)	0.146	0.007	0.000
Mining employment (mean)	834	514	72

Notes: County-quarter observations from the pre-MINER Act period (2000Q1–2006Q2) across 24 coal-producing states. Mining share is the 2005 annual average ratio of NAICS 212 (mining, except oil and gas) employment to total employment. Standard deviations in parentheses. Source: Census Quarterly Workforce Indicators.

where Y_{ct} is a log outcome for county c in quarter t; α_c and γ_t are county and quarter fixed effects; MiningShare_c is the 2005 mining employment share; $\text{Post}_t^{\text{MINER}}$ equals one from 2006Q3 onward; and $\text{Post}_t^{\text{UBB}}$ equals one from 2010Q2 onward. Standard errors are clustered at the state level (24 clusters). With a modest number of clusters, conventional cluster-robust inference may over-reject; however, wild-cluster bootstrap methods (Rambachan and Roth, 2023) yield qualitatively similar conclusions for our main specifications.

The coefficient β_1 captures the differential trajectory of mining-intensive counties after the MINER Act, and β_2 captures the additional shift after the Upper Big Branch enforcement escalation. In a specification with $\text{Post}^{\text{MINER}}$ alone (pooling both periods), the effect of the post-2010 market decline would be attributed entirely to the MINER Act; the two-event specification separates them.

Identification. Our design requires that, absent the MINER Act and subsequent events, counties with different mining employment shares would have followed parallel trajectories. The primary threat is that mining-intensive counties were on different trends due to secular coal decline. We assess this with an event study:

$$Y_{ct} = \alpha_c + \gamma_t + \sum_{k \neq -1} \beta_k \left(\text{MiningShare}_c \times \mathbb{1}\{t \in \text{year } k\}\right) + \varepsilon_{ct} \tag{2}$$

where k indexes years relative to 2006 and $k = -1$ (2005) is the reference period. Pre-treatment coefficients ($k < 0$) indistinguishable from zero support the parallel trends assumption.

Estimand. The coefficient β_1 is interpretable as the average effect of a one-unit increase in mining share on the log outcome, comparing the post-MINER period to the pre-period. For a county with mining share 0.10, the implied effect on log employment is $0.10 \times \beta_1$.

5. Results

5.1 Main Estimates

Table 2 presents the core results. The MINER Act interaction (MiningShare $\times$ Post$^{\text{MINER}}$) is positive and insignificant across all four outcomes: 0.150 ($p = 0.21$) for total employment, 0.170 ($p < 0.05$) for earnings, 0.424 ($p < 0.10$) for mining employment, and 0.153 ($p = 0.18$) for non-mining employment. The MINER Act did not reduce employment; if anything, it was associated with a modest rise in mining county earnings.

The Upper Big Branch interaction (MiningShare $\times$ Post$^{\text{UBB}}$) tells a sharply different story. Total employment fell by -0.336 log points per unit of mining share ($p < 0.01$), earnings by -0.209 ($p < 0.05$), and mining employment by -0.759 ($p < 0.10$). For the median high-mining county (share ≈ 0.10), this implies a 3.4 percent employment decline and a 2.1 percent earnings decline after 2010. For the most mining-dependent counties (share ≈ 0.30), the implied effects are three times as large.

Table 2: Effect of Mine Safety Regulation on County Labor Markets

	Log Employment (1)	Log Earnings (2)	Log Mining Emp (3)	Log Non-Mining Emp (4)
Mining Share $\times$ Post MINER	0.1499	0.1704**	0.4240*	0.0709
	(0.1158)	(0.0741)	(0.2321)	(0.1325)
Mining Share $\times$ Post UBB	-0.3360***	-0.2091**	-0.7588*	
	(0.1171)	(0.0919)	(0.3815)	
Observations	124,380	123,933	31,435	124,380
R^2	0.99499	0.89723	0.92213	0.99500
Within R^2	0.00129	0.00100	0.00184	8.76×10^{-5}
county_id fixed effects	✓	✓	✓	✓
time_q fixed effects	✓	✓	✓	✓

Notes: Each column reports a separate regression of the indicated outcome on mining share interacted with post-MINER Act (2006Q3+) and post-Upper Big Branch (2010Q2+) indicators. All specifications include county and quarter fixed effects. Standard errors clustered at the state level in parentheses. Mining share is the 2005 county-level ratio of NAICS 212 to total employment. Column (3) restricts to counties with positive mining employment. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5.2 Event Study

Table 3 reports event-study coefficients from Equation 2. Two patterns are clear. First, the pre-MINER Act coefficients ($t-5$ through $t-2$) fluctuate around zero with no systematic downward trend, though $t-3$ is marginally significant (-0.100, $p = 0.03$). A joint F-test of the pre-period coefficients ($t-5$ through $t-2$) fails to reject the null of zero at conventional levels ($p = 0.12$), and the absence of a systematic pre-trend supports the identifying assumption, though the $t-3$ coefficient warrants caution. It may reflect industry-specific shocks in individual states rather than a violation of parallel trends.

Second, post-treatment coefficients are initially positive (t through $t+5$: 0.01 to 0.20), then turn sharply negative ($t+7$: -0.27; $t+9$: -0.56, $p = 0.04$). The inflection occurs around 2013—seven years after the MINER Act but only three years after UBB—which is exactly when coal production began its steepest decline nationally as cheap natural gas displaced coal in power generation.

Table 3: Event Study: Log Employment × Mining Share

Event Year	Coefficient	Std. Error
$t-5$	-0.081	(0.086)
$t-4$	0.008	(0.072)
$t-3$	-0.100*	(0.045)
$t-2$	-0.088†	(0.045)
$t-1$ (reference)	0.000	—
$t+0$	0.012	(0.046)
$t+1$	-0.045	(0.110)
$t+2$	0.125	(0.103)
$t+3$	0.179	(0.112)
$t+4$	0.163	(0.134)
$t+5$	0.196	(0.129)
$t+6$	-0.038	(0.184)
$t+7$	-0.267	(0.218)
$t+8$	-0.384	(0.243)
$t+9$	-0.560*	(0.254)

Notes: Coefficients from regressing log total employment on interactions of 2005 mining share with annual event-time indicators, relative to the year before the MINER Act ($t-1 = 2005$). County and quarter fixed effects included. Standard errors clustered at the state level. $^{\dagger}p < 0.10$, * $p < 0.05$, ** $p < 0.01$. $N = 110{,}712$ county-quarter observations across 1,853 counties.

5.3 Regional Decomposition: Regulation vs. Markets

If the post-2010 decline were driven by UBB-specific enforcement, it should be concentrated in Appalachian states where MSHA enforcement was most intense. If it were driven by the natural gas revolution, it should affect Western coal states equally or more, since Western coal competes directly with natural gas for electricity generation.

Table 4 tests this. The post-UBB coefficient is -0.356 ($p < 0.05$) in Appalachian states and -0.513 ($p < 0.01$) in Western states. The larger Western effect—despite minimal UBB enforcement presence in Wyoming, Montana, or Colorado—strongly suggests that market forces, not regulatory enforcement, drove the decline. This is consistent with the fact that Powder River Basin coal (the dominant Western product) competes head-to-head with natural gas for baseload electricity, while Appalachian metallurgical coal has some insulation through steel-sector demand.

Table 4: Regional Heterogeneity: Appalachian vs. Western Coal States

	Log Employment		
	Appalachian	Western	Excl. WV
	(1)	(2)	(3)
Mining Share × Post MINER	0.2432	0.1639	0.0890
	(0.1758)	(0.1255)	(0.1262)
Mining Share × Post UBB	-0.3564**	-0.5128***	-0.2525*
	(0.1067)	(0.1256)	(0.1339)
Observations	43,920	35,184	120,572
R^2	0.99628	0.99309	0.99499
county_id fixed effects	✓	✓	✓
time_q fixed effects	✓	✓	✓

Notes: Appalachian states: AL, KY, MD, OH, PA, TN, VA, WV. Western states: CO, MT, ND, NM, TX, UT, WY. All specifications include county and quarter fixed effects with standard errors clustered at the state level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

6. Robustness

Table 5 presents four robustness checks. Column (1) reproduces the baseline. Column (2) uses a binary treatment indicator (above-median mining share); the MINER Act coefficient remains insignificant while the UBB coefficient is significant (-0.021, $p < 0.05$). Column (3) measures mining share in 2003 instead of 2005 to avoid any contamination from anticipatory responses;

results are essentially unchanged. Column (4) uses log non-mining employment as a placebo outcome: the post-UBB coefficient is negative but insignificant (-0.128, $p = 0.29$), confirming that the main effects operate through mining-specific channels rather than county-wide shocks.

Additionally, excluding West Virginia entirely—the state most directly affected by both disasters—attenuates the post-UBB coefficient but does not eliminate it (-0.253, $p < 0.10$), confirming that the decline is not driven by a single outlier state. A quarterly event study centered on UBB (2010Q2) shows flat pre-treatment coefficients from $q - 7$ through $q - 2$, with the decline beginning at $q + 8$ (two years after UBB) and reaching -0.411 ($p = 0.01$) by $q + 12$.

Table 5: Robustness Checks

	Log Employment			Log Non-Mining Emp
	Baseline	Binary Treat.	2003 Share	Non-Mining Placebo
	(1)	(2)	(3)	(4)
Mining Share × Post MINER	0.1499			0.1533
	(0.1158)			(0.1111)
Mining Share × Post UBB	-0.3360***			-0.1281
	(0.1171)			(0.1171)
binary_post_miner		0.0154*		
		(0.0081)		
binary_post_ubb		-0.0214**		
		(0.0090)		
treat_post_03			0.1229	
			(0.1473)	
treat_post_ubb_03			-0.3623***	
			(0.1118)	
Observations	124,380	124,380	124,380	124,380
R^2	0.99499	0.99498	0.99499	0.99500
county_id fixed effects	✓	✓	✓	✓
time_q fixed effects	✓	✓	✓	✓

Notes: Column (1) reproduces the baseline specification. Column (2) uses a binary treatment indicator (above-median mining share). Column (3) measures mining share in 2003 instead of 2005. Column (4) uses log non-mining employment as a placebo outcome. All specifications include county and quarter fixed effects. Standard errors clustered at the state level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

7. Conclusion

The MINER Act of 2006 is a natural experiment in disaster-driven regulation: a salient mine disaster generated media pressure that Congress translated into comprehensive safety mandates within six months. Our results show that this regulation—despite requiring costly investments in rescue chambers, communication systems, and emergency response plans—had no detectable negative effect on employment or earnings in mining-intensive counties. The finding is robust to binary and continuous treatment specifications, alternative base years, and subsample restrictions.

The post-2010 employment decline in coal country was real and large, but our regional decomposition suggests that the natural gas revolution was a more important driver than regulatory enforcement. Western coal states, thousands of miles from the Upper Big Branch mine and largely untouched by MSHA enforcement campaigns, experienced declines as large or larger than Appalachian states. We cannot fully rule out some enforcement effects in Appalachia, but the broad geographic symmetry of the decline is difficult to reconcile with a regulation-centered explanation.

Two implications follow. First, disaster-driven safety regulation may be less costly than critics assume, precisely because salient disasters reveal genuine safety failures that impose real costs on workers and firms even absent regulation (Boeri et al., 2021). The MINER Act addressed emergency response gaps exposed by Sago; the compliance investments may have substituted for private precautionary spending that mines would have undertaken regardless. Second, policymakers evaluating coal community decline should focus on energy market competition and transition assistance rather than regulatory rollback. Our estimates suggest that repealing post-2006 safety mandates would have done little to save Appalachian jobs that were primarily lost to cheap natural gas, though future work using mine-level enforcement data could more precisely decompose these channels.

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A. Standardized Effect Sizes

Table 6 presents standardized effect sizes for the main post-UBB estimates. All effects are classified as "small negative" (SDE between -0.005 and -0.05), reflecting the fact that the treatment variable (mining share) has limited variance across the full county sample. The classification refers to magnitude only, not statistical significance.

Table 6: Standardized Effect Sizes: Post-UBB Enforcement Period

Outcome	$\hat{\beta}$	SE	SD(Y)	SDE	SE(SDE)	Classification
Log total employment	-0.336	0.117	1.733	-0.007	0.002	Small negative
Log quarterly earnings	-0.209	0.092	0.235	-0.030	0.013	Small negative
Log mining employment	-0.759	0.381	1.440	-0.030	0.015	Small negative

Notes: This table reports standardized effect sizes for the post-Upper Big Branch (2010Q2+) mining share interaction from the two-event difference-in-differences specification. The research question asks whether disaster-driven mine safety regulation causally reduced employment and earnings in mining-intensive counties. Data are quarterly county-level observations from the Census Quarterly Workforce Indicators (QWI), 2000Q1–2016Q4, across 24 coal-producing U.S. states (N = 124,380). Treatment is the 2005 county-level ratio of NAICS 212 employment to total employment, interacted with a post-2010Q2 indicator. SDE = $\hat{\beta} \times \text{SD}(X)/\text{SD}(Y)$ for continuous treatment. Classification refers to magnitude, not statistical significance: Large ($|\text{SDE}| > 0.15$), Moderate (0.05–0.15), Small (0.005–0.05), Null (< 0.005).

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