The Mining Industry and Community Poverty Across Appalachia

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ABSTRACT

This study takes a new look at coal mining and poverty in Appalachia using interdisciplinary approaches from economics, sociology, and geography. Social scientists refer to a "natural resource curse" in which mining-dependent places tend to have poorer conditions relative to other areas. We evaluate this relationship by analyzing the present period and including the more modern influence of mountain-top-mining (MTM) with its broader environmental footprint. Independent variables include the share of employment in the coal mining industry and a gradient measure of mountain-top mining based on coal production. We also include a series of robust control-variables lagged in time to be causally prior to the dependent variables. Poverty rates for 2000 and 2010 are the dependent variables. Multivariate models were constructed for the Appalachian Regional Commission (ARC) counties (N=417) and for all U.S. counties (N=2, 611). These models explain from 88–94% of the variance in poverty rates. For ARC counties, the share of coal mining employment in 1990 is related to higher poverty in 2000 but net change in coal employment over the 1990–2000 decade has no statistically significant relationship. Outside of the ARC, the share of coal employment has no statistically significant relationship with poverty. Turning to the next decade, for the ARC counties, the share of coal employment in 2000 had no statistically significant relationship with subsequent (2010) poverty rates. For the ARC counties, coal employment also tends to be related to better local conditions relative to employment in oil/gas, as the latter sector is correlated with higher poverty in 2010. Within the ARC counties, MTM had no statistical relationship to poverty. Overall, the results suggest that coal's historically observed natural resource curse or positive relationship with poverty may be changing in the post-2000 period. To evaluate this unique relationship found in our study, future research should aim to model the potential nonrandom nature of mining location. Coal mining is determined by geology, national/global demand, and other nonrandom, local factors, including potential siting in business-friendly locales. Hence, future work should focus on the nonrandom nature of mining location such as through the use of instrumental variables to further appraise whether the effects of coal mining are truly changing.

INTRODUCTION

This study takes a new look at coal mining and poverty in Appalachia. We develop an interdisciplinary approach by building from research in economics, sociology, and geography. In doing so, we improve conceptually and methodologically on past research questioning the degree to which the coal mining industry influences poverty.

Economists, sociologists, geographers, and other social scientists have long studied poverty in Appalachia. Across the social sciences, researchers refer to a "natural resource curse" in which mining-dependent areas tend to have poorer conditions relative to other areas. The natural resource curse, however, has been analyzed mainly across nations, particularly the developing world and within the U.S. is sometimes applied to the early history of Appalachia. In this study, we integrate contemporary social science research on poverty with that pertaining to coal mining and the natural resource curse—to analyze the degree to which the coal mining industry today influences poverty.

We improve upon earlier studies in several ways. First, we analyze the impacts of coal mining employment in the present period until 2010 and we include the more modern influence of mountain-top-mining (MTM) with its broader environmental footprint. Second, we provide a nationally comparative study that not only analyzes Appalachia but compares the case of coal in Appalachia with that of other regions. Third, we add new independent, control variables pertaining to community context that include distance from urban areas, other employment including employment in oil and gas, and past history of poverty. These variables improve ability to control for potentially spurious determinants and also allow us to assess the relative performance of employment in coal compared to gas/oil in alleviating poverty. Finally, we improve upon measures of MTM used in past research (Hendryx, 2011; Partridge et al., 2013), as well as use improved measures of coal mining employment. To measure poverty, we use the official federal poverty rate measure, the proportion of an area's population whose pre-tax cash income falls below the federally-set threshold; this measure is the most commonly-used, well-established poverty measure in scholarly work and its importance is well-recognized by policymakers. Certainly researchers can construct other measures of poverty. Nevertheless, the poverty rate is a key measure in virtually all federal, state, and local assessments of well-being, and it is one of the three indicators used in the Appalachian Regional Commission (ARC) distress index. The standard federal threshold measure in 2011 was set at $11,484 for a family of one and $23,021 for a family of four (DeNavas-Walt et al. 2012:49).

We limit this study to a focus on poverty for several reasons. First, poverty has been historically one of the key indicators of well-being in Appalachia, as seen for example in President Johnson's War on Poverty in the 1960s and its use in the ARC index. Second, recent research continues to seek to disentangle the relationship between poverty and mining in Appalachia (Hendryx 2011; Partridge et al. 2013). Finally, we focus on a single indicator measure to better provide more depth of analysis over time and place. Nevertheless, it should be noted, that analysts have been concerned with mining and an array of other indicators of well-being.

Research on the natural resource curse by economists has typically focused on economic growth indicators and diversity of economic sectors (James and Aadland 2011). Partridge and Rickman (2006) show that poverty is an outcome of economic growth: thus poverty can be considered as a down-stream indicator of the conventional natural resource curse. Sociologists have stressed not only growth and diversity, but distribution (such as poverty), social disruption, and environmental degradation as indicators of well-being affected by natural resource extraction (Stedman et al. 2012). Our study is thus necessarily limited in its consideration of well-being and future work should build on a wider-range of indicators.

This paper first provides a brief overview of the conceptual and methodological issues important for social science assessment of the impacts of the mining industry on community well-being. The second section documents the steps to address some of these issues and provides an empirical demonstration. We present ten quantitative analyses that assess the extent to which poverty rates across communities are related to the mining industry.

SOCIAL SCIENCE CONCEPTUAL ISSUES IN ASSESSING IMPACTS OF MINING

Economists, sociologists, and geographers have long analyzed the impacts of different employment sectors on poverty and other indicators of community well-being (Brown et al. 2005; Lobao 1990; Lobao, Hooks, and Tickamyer 2007; Partridge and Rickman 2006). Drawing from this past research, we denote key issues that need to be considered in empirical research aimed at evaluating the influence of the mining industry.

(1) Community-specific issues pertaining to selection bias need to be considered. By selection bias, we refer to the degree to which past community conditions (such as the presence of coal deposits, previous socioeconomic conditions, and population demographic attributes) have influenced the location of the mining industry. Appalachian coal mining is concentrated in some of the nation's poorest counties. Some researchers suggest coal mining may be a cause of these very poor conditions (Hendryx 2011). Yet, coal mining elsewhere in the United States is not associated with such geographical clusters of poverty (e.g., coal mining in Wyoming and much of the Great Plains). Thus, it is reasonable to question whether coal mining is the ultimate "cause" of abject conditions in parts of Appalachia or whether other persistent factors cause these pockets of poverty. In the effort to sort out this causal relationship, researchers must deal with the issue of endogeneity: in this case, poor communities in the past may have adopted coal development but coal mining today does not causally determine poverty. For example, there are host of reasons that could explain why coal mining communities in Appalachia are poor. Foremost are their general remoteness from large cities and a workforce with inadequate education. In addition, poor communities may be prone to accept coal development as an avenue for new jobs. This relationship was suggested by Gould (1991)in a series of case studies of mining dependent areas. Here coal mining would not be the cause of deprived development, but rather an outcome of the process. Hence, robust research is necessary to uncover coal mining's ultimate impact. Still, it needs to be recognized that the issue of endogeneity (i.e., establishing causality) affects virtually all social science studies, ours included. It is an inherent problem for studies assessing the impacts of economic and social processes across communities that researchers must take steps to minimize.

(2) The time period of focus and changes in relationships over time need to be considered. Past community conditions likely carry forward to influence present-day levels of poverty net of mining itself. Extant studies on mining in Appalachia have addressed its impacts on poverty rates usually through cross-sectional and/or correlational-type analyses (e.g., Hendryx 2011). A more robust empirical approach is needed that takes into account past local conditions. Further, mining may not have consistent effects across time. As the industry has required more skilled, higher paid labor, its impacts on communities may have improved in recent years.

To address, issues (1) and (2) in our empirical analyses, we first describe the degree to which poverty and other conditions were different (a priori) in counties characterized by mining operations, including mountaintop mining. We use control variables lagged in time back to 1990 where possible to control for past conditions and to omit reverse causality. For example, we use lagged poverty rates to control for whether poverty initially was higher in coal mining counties. Other persistent economic conditions are measured by past job growth of the county. We also include the presence of other mining in gas/oil as proportion of county employment, to assess the comparative impacts of other energy industries. Also included as control variables are demographic attributes of race/ethnicity, age, education, and family structure and a detailed mix of population agglomeration variables pertaining to distance and size of the nearest metropolitan areas. Past research finds that poverty rates are positively associated with distance from metropolitan areas (all else equal) (Partridge and Rickman 2008a). Finally, to assess the degree to which the impacts of mining might vary over time, we examine two time periods, the respective decades of 1990–2000 and 2000–2010.

(3) Comparisons to other U.S. places are also needed. With regard to Appalachia as a whole, socioeconomic conditions in mining communities may not be much different from conditions in other communities. Conversely, rural Appalachian communities potentially have experienced more severe declines in sectors such as manufacturing relative to mining in recent decades; mining in fact may be a buffer to decline. As noted above, comparing relationships between Appalachia and other regions is important. Should coal mining be associated with higher poverty in Appalachia but not in other regions, this would suggest some unique attributes of Appalachia may be driving the results.

In summary, research is needed to: identify coal mining's impacts using methodological approaches that go beyond extant correlational designs; evaluate whether the effects of coal mining employment are shifting over time; and assess whether relationships found in Appalachia persist in other parts of the country. The analyses below move in these directions.

EMPIRICAL ANALYSES: COAL MINING EMPLOYMENT, MOUNTAIN-TOP MINING, AND POVERTY

Modeling Approach and Empirical Implementation

Our modeling approach follows that taken in a previous study of mining and poverty by Partridge, Betz, and Lobao (2013) and developed from other published poverty studies (Levernier, Partridge, and Rickman 2000; Partridge and Rickman 2005, 2008a). The aforementioned studies use a disequilibrium partial-adjustment model in order to evaluate poverty relationships across geographic space, using counties as the unit of analysis. The model assumes each county's poverty rate is a function of its characteristics such as job growth, and demographic, geographic attributes. These characteristics influence the county's poverty rate over time, though there may be a significant time-lag between changes in these characteristics and the actual poverty rate itself. For example, when college degree attainment-levels increase, it may take years before more educated workers are employed in better paying jobs and the poverty rate declines. Because of the sluggish adjustment to a new equilibrium poverty rate, the current poverty rate is assumed to be a function of the past poverty rate as well as current demographic, economic, and geographic attributes. For further details about the modeling approach, see Partridge, Betz and Lobao (2013). Below we provide a brief overview of the empirical implementation of the modeling approach.

The empirical models are estimated with ordinary least squares (OLS) and state-fixed effects. OLS models have shortcomings that we try to mitigate, one concern being endogeneity discussed above which raises concern about reverse causality. Generally, we time-lag the independent variables to reduce the concern with reverse causality.

Two samples are analyzed: (1) Appalachian counties as designated by the Appalachian Regional Commission (ARC counties) and (2) all other US counties. A finding that coal mining has a different effect in the rest of the US compared to the ARC region would suggest that coal mining may not be the cause of high poverty, but possibly something else uniquely related to Appalachia (e.g., regional institutions, culture or historic remoteness). Deaton and Niman (2012) find that coal mining is associated with high-levels of persistent poverty in the ARC region. Further, James and Aadland (2011), Papyrakis and Gerlagh (2007), and Kilkenny and Partridge (2009) find evidence of a "natural resources curse" whereby mining has a similar (generally negative) effect on economic well-being across the country (and the world).

The dependent variable is the total (individual) poverty rate, measured for two time periods (2000 and 2010). We measure it using data from the 2000 Census, where data refers to the previous year's poverty threshold (we refer to it as the 2000 poverty rate) and we measure the 2010 poverty rate from the U.S. Census Bureau SAIPE. We first estimate a base model with (non-mining) independent variables following Partridge, Betz, and Lobao (2013); then we add the *MINING* employment and mountain-top/intrusive surface mining *MTM* variables, the model taking the form:

$$\begin{aligned} POV_{it} = {} & \alpha POV_{it-10} + \beta MTM \\ & + \varphi MINING \\ & + \psi MTM * MINING \\ & + \lambda AVGNEIGHPOV_{it-10} \\ & + \gamma PROXIMITY_i + \theta CITYTYPE_i \\ & + \delta ECON_{it-10} + \phi DEMOG_{it-10} \\ & + \sigma_s + \varepsilon_{it} \end{aligned} \quad (1)$$

where POV_{it-10} is the ten-year lagged poverty rate measured in 1989 (from the 1990 Census) for the 2000 poverty rate model and measured in 1999 (from the 2000 Census) in the 2010 poverty rate model. Regression coefficients are represented by, α, β, φ, ψ, λ, γ, θ, δ, and ϕ. State fixed effects are represented by σ_s to capture factors associated with each state such as welfare policies, tax and regulatory policies, and cultural and historic factors such as those found in Central Appalachia. The error term is denoted by ε_{it}, which we assume is heteroskedastic. We correct for heteroskedasticity by estimating robust standard errors.

We measure mining through indicators of employment and mountain-top/other intrusive surface mining. For mining employment activities, we include three (place of work) employment shares for (1) coal mining; (2) oil and gas mining, and (3) other mining activities using four digit NAICS codes using data from EMSI consulting company.* We also include the ten-year percent change in the three mining sector's county employment shares (1990–00 and 2000–10), which should be exogenous because these goods are almost exclusively traded on national international markets. Thus, we account for lagged historic effects of mining and the contemporaneous effects of recent changes in mining employment—i.e., do new mining operations have different marginal effects than long-term legacy effects. By separating the three mining industries, we also can ascertain whether coal mining has different effects. Mountain-top/other intrusive surface mining (MTM) is measured by a continuous variable we developed from the United States Energy Information Association's FERC-423 data. This improves upon the standard presence/absence of MTM used in some studies

* EMSI uses other data sets and an algorithm to estimate values for data suppressed in the U.S. Department of Labor's *Quarterly Census of Employment and Wages*—see Dorfman et al. (2011) for more details. The county share of coal employment is calculated as follows. Total employment in coal mining employment (NAICS 2121) is used as our base value for coal mining employment. To this value we add an estimate of county employment in coal mining support activities. Our employment data is only detailed to the 4-digit level, which gives us information on total mining support employment (NAICS 2131), but not coal mining support employment (NAICS 21314), which is recorded as a 5-digit NAICS category. To derive a county estimate for employment in coal mining support we calculate the share of mining support employment attributable to coal mining support employment at the national level using publicly available data from the Bureau of Labor Statistics. We multiply the national share of mining support attributable to coal mining support by the county's employment in mining support to derive an approximate measure of county employment in coal mining support activities. We add this to our base value of coal mining employment and divide by total county employment to get the share of county employment attributable to coal mining and coal mining support activities. By contrast, Partridge et al. (2013) did not adjust for coal mining support activities, though this is a small share of coal employment.

by allowing for a gradient measure and allows us to capture the intensity of surface mining in more mountainous counties. This improves upon the rough measure of the simple existence of mountain-top mining based on satellite data (e.g., see Hendrxy, 2011; Partridge et al., 2013), including giving MTM a slightly larger geographical scope. The USEIA generated data has information on where the coal originates and whether underground or surface mining was used. The USEIA data does not distinguish mountain-top mining specifically from other surface mining so we consider them in aggregate. Although this also includes contour mining or contour auger mining, they are all intrusive and disruptive forms of mining. In order to develop a gradient measure, we then consider positive values of surface mining for counties that have a USDA ERS topography code>18, ("high-elevation mountainous counties"), assigning counties with a topography code<18 a value of zero. The measure we create is the total quantity of surface mining measured in tons of coal for high elevation counties. We also interact the MTM variable with the coal mining employment variable. This allows us to parse out whether the effects of the level and growth of coal mining are different in MTM counties.

Based on extant research, it is not clear *a priori* whether the mining industry has a positive or negative overall effect on poverty rates. For example, increased mining activities will likely provide jobs. Black et al. (2005) find that about 100 new coal mining jobs provided on net about 25 additional indirect jobs in Appalachian coal communities. However, in terms of attracting population and reducing poverty, it is not clear whether these economic benefits outweigh the negative environmental and health externalities often associated with mining.

Our empirical models also include key variables that social scientists identify as important control variables in regional poverty studies (Blank 2005; Glasmeier 2002; Partridge and Rickman 2006; Weber et al. 2005). We employ the same control variable measures as those used by Partridge, Lobao, and Betz (2013). Further detail on data sources and measures of the variables are provided in Partridge and Rickman (2005, 2008a). *AVGNEIGHPOV* is the average poverty rate of counties contiguous to county *i* measured in 1990 to account for spatial spillovers across counties. *PROXIMITY* is a vector of distance variables that reflect remoteness to increasingly larger cities. Proximity to urban agglomeration economies tends to provide better employment opportunities for workers near the poverty line, while communities themselves benefit from stronger commuting linkages, knowledge spillovers, and tighter input-output linkages with a larger set of suppliers and consumers nearer the urban core. Agglomeration measures include distance in kilometers to the nearest metropolitan area as well as to larger metro areas. *CITYTYPE* is a vector that includes the lagged county population and measures of city-size within counties. The *ECON* vector contains measures of local job growth from the U.S. Bureau of Economic Analysis data (BEA) based on growth over the five years directly prior to the poverty measurement and then five years prior to that. So for the 2000 poverty model, employment growth was measured over 1990–1995 and 1995–2000. Demographic composition differences are controlled with the *DEMOG* vector that includes age, race, education, immigration, and single-parent households. Demographic variables are also lagged ten years prior to the dependent variable (i.e., measured in 1990 or 2000) to mitigate concerns about endogenous relationships with the dependent variable.

Descriptive Statistics

Figures 1a and 1b show coal mining's share of total county employment for 1990 and 2000 in the Central Appalachian region. In cross-hatching, we display whether or not the county had a positive value for our mountaintop mining variable. These counties have both positive values for surface coal mining and a USDA ERS topography code greater than 18. Consistent with the long-term trend of declining economic importance of coal mining in the region over the past 60 years, the maps show fewer counties with coal employment shares above 16% of total employment in

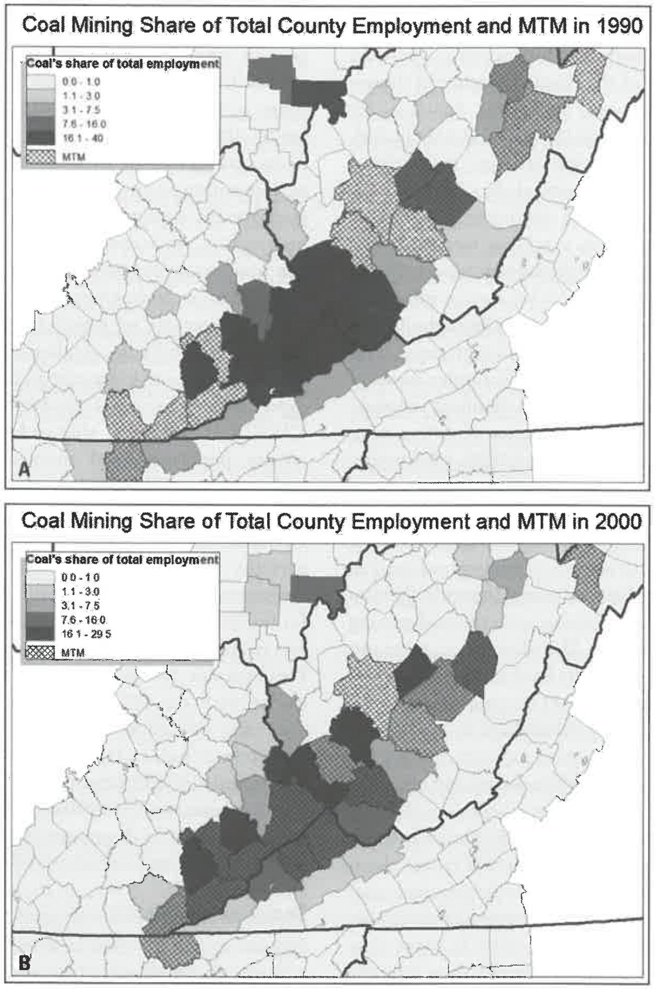

Figure 1. Central Appalachia

2000 than in 1990 as well as fewer counties for which employment in coal mining constitutes more than one-percent of total employment.

Table 1 contains selected descriptive statistics for the ARC, the rest of the U.S, and Central Appalachian MTM counties for 1990 and 2000. The lowest poverty rates occur in the rest of the U.S. with higher rates in the ARC region, and the highest rates in MTM counties. The latter counties have the greatest average distance to the nearest metropolitan area, suggesting predominantly remote, rural areas that would face significant economic barriers. The ARC region has slower employment growth than the rest of the U.S. and MTM counties have the slowest job growth.

Table 1. Selected descriptive statistics by region: 1990 and 2000

	US			ARC			MTM		
	1990	2000	2010	1990	2000	2010	1990	2000	2010
Poverty	16.34	13.78	16.37	19.06	16.38	19.52	30.04	26.34	25.06
	(7.79)	(6.38)	(6.17)	(7.90)	(6.39)	(5.38)	(7.25)	(6.31)	(5.41)
MTM	0.12	0.11		1.15	1.65		13.01	19.23	
	(3.85)	(4.01)		(6.54)	(10.97)		(18.83)	(33.15)	
Km to nearest MA	74.41			53.02			72.08		
	(62.10)			(31.85)			(26.33)		
Incremental distance MA of 250k	61.84			22.7			3.06		
	(103.27)			(31.02)			(9.62)		
Incremental distance MA of 500k	41.12			38.68			116.84		
	(69.19)			(50.85)			(60.12)		
Incremental distance MA of 1.5m	88.48			99.39			64.38		
	(121.57)			(98.25)			(72.18)		
Nearest metro population	455,918			213,224			193,341		
	(1,460,000)			(346,714)			(84,147)		
Employment growth 1990–95 (2000–05)	11.25	3.06		9.25	2.29		5.67	0.57	
	(18.62)	(10.94)		(9.41)	(9.67)		(9.27)	(7.40)	
Employment growth 1995–2000 (2005–2010)	9.43	1.26		7.58	–1.45		1.00	–0.38	
	(9.97)	(7.76)		(10.67)	(6.84)		(7.40)	(6.49)	
Percent high school graduate	34.35	34.39		34.55	37.4		30.01	34.44	
	(6.02)	(6.44)		(6.73)	(6.41)		(4.29)	(4.29)	
Percent some college	17.07	21.1		12.14	16.05		10.28	13.73	
	(4.33)	(4.10)		(2.94)	(3.12)		(2.03)	(2.35)	
Percent associates degree	5.55	5.85		4.06	4.8		2.69	3.63	
	(2.10)	(1.99)		(1.63)	(1.66)		(1.03)	(1.11)	
Percent college grad	13.89	16.97		10.48	12.96		7.63	9.23	
	(6.51)	(7.75)		(4.97)	(5.89)		(2.41)	(2.83)	
Percent female-headed HH with children	5.46	6.15		5.19	5.74		6.12	6.12	
	(2.35)	(2.43)		(1.58)	(1.65)		(1.02)	(0.94)	
Percent male-headed HH with children	1.37	2.12		1.3	1.98		1.4	1.9	
	(0.56)	(0.65)		(0.42)	(0.50)		(0.47)	(0.48)	
Percent under age 6	10.23	9.05		9.13	8.56		9.1	8.29	
	(1.44)	(1.47)		(1.08)	(1.10)		(0.93)	(0.61)	
Percent age 7–17	16.89	16.72		16.16	15.17		18.61	15.29	
	(2.40)	(2.03)		(1.80)	(1.45)		(1.30)	(1.19)	
Percent age 18–24	8.99	8.81		10.29	9.18		9.74	9.12	
	(3.43)	(3.33)		(3.23)	(3.27)		(1.02)	(0.69)	
Percent age 60–64	4.69	4.45		4.81	4.82		4.5	4.67	
	(1.01)	(0.98)		(0.73)	(0.76)		(0.53)	(0.49)	
Percent over age 65	15.06	14.87		14.38	14.6		12.59	13.54	
	(4.52)	(4.26)		(2.65)	(2.74)		(2.08)	(1.77)	
N	2,596	2,596	2,596	413	413	413	37	37	37

Notes: See the text or Partridge and Rickman (2005, 2008a, 2008b) for more details of variable definitions.

Table 2. Determinants of 2000 (1999) poverty rates

	(1) Base		(2) Levels and Change		(3) MTM
	US	ARC	US	ARC	ARC
Poverty rate 1990	0.53‡	0.59‡	0.53‡	0.59‡	0.58‡
	(25.95)	(12.96)	(25.97)	(12.89)	(12.70)
MTM					0.01
					(0.44)
MTM*share coal					–2.2e–03
					(–1.56)
MTM*change coal					–4.4e–05
					(–0.16)
Share coal	0.02	0.09‡	0.02	0.09‡	0.12‡
	(0.50)	(2.74)	(0.50)	(2.76)	(3.10)
Share oil and gas	0.04†	–0.02	0.04†	–0.01	–0.02
	(2.09)	(–0.33)	(2.03)	(–0.29)	(–0.40)
Share other mining	4.8e–03	–0.13	4.60E–03	–0.15	–0.15
	(0.29)	(–1.27)	(0.28)	(–1.37)	(–1.37)
Change in coal 1990–2000			–1.7e–05‡	2.6e–04	2.6e–04
			(–2.90)	(0.65)	(0.67)
Change in oil and gas 1990–2000			–4.3e–05	1.4e–04	1.5e–04
			(–0.34)	(0.43)	(0.44)
Change in other mining 1990–2000			1.1e–06	–1.2e–04	–1.3e–04
			(1.41)	(–0.33)	(–0.37)
N	2611	417	2611	417	417
R–sq	0.908	0.932	0.908	0.932	0.933

Notes: See the text or Partridge and Rickman (2005, 2008a, 2008b) for more details of variable definitions.
All standard errors are robust.
* p<.10, † p<.05, ‡ p<.0

Results from the Empirical Models

Table 2 displays the results for the determinants of 2000 county poverty rates for the ARC sample and the rest of the U.S. sample. Both samples include two base specifications, with an additional model for the ARC sample that includes MTM and the MTM interaction variables. To condense discuss and better focus on the mining results, the tables report only the results for those variables (net of other control variables above that are also included in the estimations).

The models in Table 2 perform quite well, explaining over 90% of the variation in the dependent variable. Consistent with theory, lagged poverty rates are positively and significantly related to current poverty rates. Persistence is greater in ARC counties compared to non-ARC counties, consistent with the long-term disadvantages felt in the region. For the base models (1), share of oil/gas is statistically significant for the U.S. 2000 model but coal is not. This relationship is interesting for it shows that coal may perform better for well-being than other types of mining. Conversely in ARC counties, coal mining's employment share is positive and statistically significant but the other mining shares are statistically insignificant. These results support the view that coal mining in Appalachia is associated with higher poverty, but the same does not apply elsewhere in the U.S.

Models 2 (Table 2) add the corresponding ten-year percent change in county shares of coal mining, oil and gas mining, and other mining to the model. For the U.S. sample, poverty has a negative relationship with change in mining employment shares. For the ACR, there is no statistical association between percent change in mining employment shares and poverty. These

Table 3. Determinants of 2010 poverty rates

	(1) Base		(2) Levels and Change		(3) MTM
	US	ARC	US	ARC	ARC
Poverty rate 2000	0.69‡	0.56‡	0.69‡	0.56‡	0.56‡
	(30.40)	(9.97)	(30.30)	(9.90)	(9.85)
MTM					4.3e–03
					(0.22)
MTM*share coal					–3.4e–04
					(–0.54)
MTM*change coal					–9.6e–05
					(–0.45)
Share coal	–0.14‡	–0.05	–0.14‡	–0.05	–0.05
	(–2.74)	(–1.30)	(–2.74)	(–1.30)	(–0.82)
Share oil and gas	–0.08‡	0.13†	–0.08‡	0.13†	0.12†
	(–3.03)	(2.20)	(–3.02)	(2.16)	(2.11)
Share other mining	–0.02	–0.18	–0.02	–0.19	–0.19
	(–1.09)	(–1.49)	(–1.09)	(–1.57)	(–1.57)
Change in coal 2000–2010			–1.4e–06†	–6.8e–07	–6.4e–07
			(–2.51)	(–0.56)	(–0.52)
Change in oil and gas 2000–2010			–7.9e–09	4.7e–06	2.9e–06
			(–0.12)	(0.04)	(0.02)
Change in other mining 2000–2010			–4.1e–06	–5.6e–05*	–5.6e–05*
			(–0.54)	(–1.78)	(–1.77)
N	2611	417	2611	417	417
R–sq	0.902	0.884	0.902	0.884	0.884

Notes: See the text or Partridge and Rickman (2005, 2008a, 2008b) for more details of variable definitions.
All standard errors are robust.
* p<.10, † p<.05, ‡ p<.0

results suggest that poverty's association with coal mining is more of a legacy effect than an association with increases in coal production over the 1990–2000 period.

Model 3 shows no statistically significant relationship between MTM and 2000 ARC poverty rates. We also interact the MTM indicator variable separately with coal's share of total employment and the percent change in coal's share of total employment. Again these terms are not statistically significant and suggest MTM has no additional impact on poverty. We point out, however, that our measure of MTM does not control for non-random selection of MTM sites. Companies interested in carrying out MTM may strategically pursue counties with certain demographic, geographic, or economic characteristics that are in turn associated with poverty rates. To deal with these selection issues, further analysis using more sophisticated statistical techniques, such as instrumental variables, is necessary.

With regard to other (control) variables, though we do not display results, we note that most have results similar to those of Partridge and Rickman (2008a, 2008b). In particular, these results highlight the statistically significant effects of distance and education. That is, poverty rates are positively related to distance to higher tiered MAs and to a smaller share of the adult (age 25 or over) having completed high school and college. The effects of education and distance are important because most mining operations are located in remote rural areas with less educated populations. Such variables are important to control for effects that may bias the MTM and other mining variables.

The regression results for the 2010 poverty model are reported in Table 3. Past poverty is again a significant contributor to current poverty, but unlike the 2000 poverty model, persistence is higher in the rest of the U.S. compared to the ARC region. It is significant that ARC counties are less tied to past poverty rates in the 2000s compared to the previous decade because that implies the region may be breaking its historical disadvantages. For the ARC counties, in both Models 1 and 2, the positive relationship between coal mining's share of total employment and poverty in the 2000 poverty model disappears in the 2010 poverty model as the relationship is no longer significant. Further, the coal employment share relationship is negative and statistically significant in the 2010 U.S. model. This suggests that the negative legacy of large coal operations may be dissipating over time. In Model 2, percent change in coal employment now has a negative and significant relationship with poverty in the rest of the U.S. Interestingly, the share of oil and gas mining now has a positive and significant relationship with poverty in the ARC model. Mountain-top mining further has no significant relationship with poverty, suggesting that at least in the short term, MTM has a similar relationship to poverty as coal mining in general. These results suggest the historic legacy of coal mining being associated with higher poverty in Appalachia may be dated.

It should be noted that distance and education both have significant effects in the 2010 poverty model, but the influence of remoteness has lessened. All levels of education still have a positive and significant relationship to poverty, but it seems the poverty-reducing threshold for education has moved from a high school diploma to an Associate's degree (in the U.S. and ARC region). This is consistent with the larger trend of decreasing employment in goods-producing sectors and increased demand for higher skilled labor.

CONCLUSIONS

In this study we examine a cross-disciplinary social science research question: does mining adversely affect population's well-being? Often framed as the "natural resource curse," this question has been studied globally across nations and conventionally assumed to apply to the case of coal mining regions in Appalachia. We report the results from a pilot-study aimed at improving past research on the coal industry. Our study: uses a robust set of control variables lagged in time to improve causal understanding; compares Appalachia with the rest of the nation for two time periods; and analyzes mountain-top mining as a gradient measure that better reflects its intensity. For ARC counties, we find that coal employment did have a positive relationship to poverty rates in the past (i.e., prior to 2000). However, over the last decade, the share of coal employment has no statistically significant relationship to poverty. Neither do we find mountain-top mining related to poverty in the ARC in either of the two time periods analyzed. It should be noted that the MTM variable is a gradient measure that measures the intensity of surface mining. It is different from the binary measure that we used in a previous study (Partridge et al. 2013) which produced different results. In the previous study, the binary measure was negatively related to poverty (and statistically significant) for 2010. These differences illustrate why careful replication across different research designs is needed to uncover the true effects of coal mining.

Further, we find the impact of coal mining in the ARC counties appears to diverge from its impact in other U.S. regions. Outside Appalachia, the share of coal employment is related to lower poverty in the contemporary (2010) period and increases in coal employment are related to lower poverty rates over time. This indicates processes unique to Appalachia beyond mining per se may be influencing the conventionally assumed link between poverty and mining.

Future social science research needs to sort out the causal impacts of coal employment and other coal mining indicators in more depth and detail. In our future work, we will build on the results of this study to develop improved methodological designs to better address cause-effect issues (i.e., endogeneity) which is an inherent concern of all empirical studies of the mining industry. Such designs include development of instrumental variable approaches.

Finally, future research should give greater focus to the coal industry's impact on other well-being indicators such as local economic growth and diversity and environmental conditions; and coal mining employment relative to other traditional industries in Appalachia such as manufacturing, which has experienced long-term decline, and to expanding employment in shale gas. We find some evidence that relative to gas/oil mining, coal mining has more positive effects on economic well-being in Appalachia. More attention is needed to comparing coal mining employment today to other sectors affecting the region's development.

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