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Coal mining, economic development, and the natural resources curse☆

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ABSTRACT

Coal mining has a long legacy of providing needed jobs in isolated communities but it is also associated with places that suffer from high poverty and weaker long-term economic growth. Yet, the industry has greatly changed in recent decades. Regulations, first on air quality, have altered the geography of coal mining, pushing it west from Appalachia. Likewise, technological change has reduced labor demand and has led to relatively new mining practices, such as invasive mountain-top approaches. Thus, the economic footprint of coal mining has greatly changed in an era when the industry appears to be on the decline. This study investigates whether these changes along with coal's "boom/bust" cycles have affected economic prosperity in coal country. We separately examine the Appalachian region from the rest of the U.S. due to Appalachia's unique history and different mining practices. Our study takes a new look at the industry by assessing the winners and losers of coal development around a range of economic indicators and addressing whether the natural resources curse applies to contemporary American coal communities. The results suggest that modern coal mining has rather nuanced effects that differ between Appalachia and the rest of the U.S. We do not find strong evidence of a resources curse, except that coal mining has a consistent inverse association with measures linked to population growth and entrepreneurship, and thereby future economic growth.

1. Introduction

Nations globally are undergoing an energy revolution that is not only altering the international geopolitical balance but also the economic landscape of energy producing communities. The related effects are producing winners and losers *between* regions as well as *within* affected U.S. communities. Factors underlying this revolution in the U.S. include (1) the Clean Air Act of 1990 that increased demand for low-sulfur Western coal at the expense of Appalachian coal; (2) innovations in unconventional drilling in shale formations for oil and natural gas that began in the late 1990s; (3) U.S. climate change policies to reduce carbon which would further increase demand for natural gas relative to coal; and (4) growing demand for natural gas and coal in India and China (EIA, 1999, 2005, 2013). The transformation of the U.S. energy sector raises a critical need to identify the impacts of energy development across the nation and particularly for communities in Appalachia that have historically been influenced by coal and where new shifts in the energy industry may be altering regional economic well-being.

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In particular, understanding the economic effects of policies aimed at limiting carbon and coal mining on local communities affected is urgently needed.

The federal policy environment, the Great Recession, along with the falling prices of now abundant natural gas, diminished demand for coal after 2008. Coal consistently accounted for 48% to 53% of U.S. electricity generation from 1990–2008 before falling to 37% in 2012; by contrast, natural gas's share of electricity production rose from 12% in 1990 to 30% in 2012 (EIA, 2013). The U.S. Energy Information Agency forecasts natural gas to be the most-used fuel for electricity generation by 2035. However, regulatory changes affected energy production long before the energy revolution. For one, the Clean Air Act of 1990 helped redistribute coal production from Appalachian to Western regions. Appalachia's share of coal production fell from 43% in 1997 to 28% in 2012 and the Western share rose from 41% to 53% (EIA, 2014). While aggregate U.S. gross coal production fell 7% over this period, Appalachian coal production fell by 37% and Western production rose 20% before peaking in 2008. Thus, depressed Appalachian communities have experienced additional pressure as the region's coal production began to lag long before the natural gas boom spread nationally.

As electricity producers substitute away from coal toward natural gas, coal jobs are eliminated and natural gas jobs are created. The result is that while there has been a (gross) expansion of jobs related to the recent shale oil and gas boom, many of these jobs have come at the expense of falling employment in the coal industry. This shift may produce net positive or negative local economic effects depending on factors such as each industry's relative capital intensity, supply chain size, and the proportion of jobs that go to local residents versus transient workers. Communities in the midst of the shale energy boom have seen economic growth – e.g., the Eagle Ford region in Texas and the Marcellus Shale region, but many of these jobs are offset by falling coal employment elsewhere.

These new and diverging trends within the energy sector suggest an urgent need to identify the community impacts of energy development, especially at a research scale that considers the entire nation. However, research on the recent energy boom is surprisingly sparse. Most studies focus on the pre-boom period that are less germane to trends associated with new technologies. Other related research examines general boom/bust cycles in energy and whether there is a "natural resources curse" in which natural resource intense locations appear to have lower long-run growth rates when averaging over the boom-bust cycle (Van der Ploeg, 2011). Some regional shale based research exists. Weber (2012) examines the shale gas boom in Colorado, Texas, and Wyoming and finds modest employment effects below those reported by industry sponsored research. Weinstein and Partridge (2011) examine the initial effects of the Pennsylvania Marcellus shale boom. They likewise find modest employment effects but also robust income growth effects presumably due to high royalty/lease payments and wages in the industry, though these studies examined more the short- to medium-term impacts of extraction.

In the case of coal, research scrutinizing the industry's recent economic effects is rare. Most prior studies focus on the boom/bust of the 1970s and 1980s (e.g., Black et al., 2005a) or on the long-run 20th century natural resources curse (Deaton and Niman, 2012). Yet questions associated with recent coal production are pivotal to America's energy economy. First, with intense competition from natural gas and a challenging regulatory environment, coal mining communities face tremendous pressures for which it is important to understand losers as well as winners. Second, the modern coal industry may have long-term effects different from those in the past which could challenge the prevailing understanding of the natural resource curse. In this manner, the industry has undergone tremendous technological change with falling employment and increased capital-intensive techniques such as mountain-top mining. Finally, as noted above, there has been a spatial redistribution of the industry with production moving west. Thus, the impacts of the coal industry are likely quite different now across both time and space.

In this study, we take a new look at the coal industry by assessing its net impacts on local communities today and providing unique contributions that respond to gaps in past work. First, we appraise a variety of indicators of economic well-being that include employment, population, and income distribution. These indicators allow us to assess not only coal mining's effects *between* communities – but also the winners and losers *within* communities. Second, we treat two distinct epochs of energy development: 1990–2000 – a period of low coal prices but modestly rising production; and 2000–2010 – a period of higher coal prices but more stable production. Third, the analysis examines Appalachia separately from the rest of the United States and contributes to assessing short-term as well as long-term effects associated with the natural resources curse. Fourth, we make summary comparisons with the impacts of the oil and gas industry; few if any past studies assess the performance of coal relative to these sectors. Finally, a key advantage of our empirical analysis is the use of instrumental variables in accounting for the non-random location of coal mining. We consider exogenous geological instruments both for the quantity of coal as well as the quality of coal. In doing so, we contribute to the emerging methodological literature measuring the impact of energy development.

In what follows, we first review the literature and evaluate recent trends in the coal industry. The conceptual model is then explained, followed by sections that discuss the empirical model, empirical results, and research conclusions.

2. Previous literature

Recent interest in the impacts of natural resource extraction on economic development has shifted from cross-country research to subnational analyses of local economies. Scrutinizing the economic impacts of natural resource extraction at a regional level is important in part because factors salient at a national level (e.g. civil wars and exchange rates) play less confounding roles. Further, because the impact of natural resource extraction on local economic outcomes is highly dependent on context (i.e. the resource being extracted, the specific economic outcome, and the local setting), subnational studies provide a finer resolution of the specific situation. As subnational research has expanded, nuances about diverse contexts as well as the identification of broad patterns that hold across contexts have begun to emerge. Below we summarize findings for the most recent investigations of economic outcomes at a subnational level. They generally point to short-term employment and wage increases, especially during boom periods, but are mixed for long-term outcomes in natural resource dependent areas.

The impact of natural resource booms on employment or wages both in the energy and non-energy sectors are investigated in several recent studies. Marchand (2012) analyzes the effects of oil and gas extraction in Western Canada on employment and earnings in the energy sector. Energy sector employment and earnings rose in boom periods, while decreases during the bust were not statistically significant. Marchand (2012) also finds the positive employment and earnings effects spill over into non-energy industries such as construction, retail trade, and service sectors during the boom, though some of the spillover gains are lost during the bust. Weber (2012) investigates the employment, income, and poverty effects of shale oil and gas drilling in the Western U.S. states of Colorado, Texas, and Wyoming. He uses a triple-difference model with instrumental variables to control for endogenous factors that might be correlated with shale development in drilling counties. He finds the value of gas produced has positive effects on employment, wages, and median household income over the 1998–2008 boom period, although the results are more modest for employment. Using a similar instrumental variable approach, Brown (2014) found that communities situated near oil and gas shale booms also experience positive income and employment effects but the employment effects are mainly concentrated only within the mining sector.

Because of their focus on coal, Black et al.'s (2005a) study is particularly germane to our research. The authors use the presence of coal reserves as an instrumental variable to determine differences in employment, earnings, and earnings per worker between coal and non-coal dependent counties in Kentucky, West Virginia, Ohio, and Pennsylvania. They examine the boom period of the 1970s, comparing the findings to the bust period of the 1980s. Wages and employment in the energy sector did indeed grow faster in coal counties than non-coal counties during the boom; however few positive spillovers into the non-traded sector or negative spillovers into the traded sectors were found. Of course, given the vast technological changes and different regulatory environments, it is unclear how much Black et al.'s (2005a) study would generalize today, especially since it did not consider the entire United States. In a more recent study, Douglas and Walker (2012) found that annual per-capita income growth between 1970–2009 was about 0.3% to 0.4% less in core Appalachian counties that ever had coal production as compared to otherwise equal Appalachian counties. However, higher (global) energy prices mitigate these effects presumably because they stimulate short-term coal development, as consistent with a boom-bust effect.

The aforementioned studies are concerned mainly with boom or bust periods that span a decade or two. But they do not address the question of long-term viability of natural resources extraction as a regional development strategy. Michaels (2011) investigates the long-term consequences of natural resource extraction by analyzing southern U.S. counties overlaying significant oil reserves in 1890. By 1990, counties overlaying oil reserves had higher per capita incomes, larger populations, and more public infrastructure compared to other southern U.S. counties without oil resources. Yet, these positive effects begin to wane around 1960. Michaels' (2011) study is limited insofar as it does not address the timing of when the region experienced energy development and the size of the impact, such as measured by the share of "energy" employment. Peach and Starbuck (2010) find oil and gas extraction had a positive long-term association with income, employment, and population for New Mexico from 1960–2000.

Recent studies have raised concerns about the longer term economic outcomes and distributional effects of high-intensity natural resource extraction. For instance, though Black et al. (2005a) report positive employment spillovers into local non-traded sectors during the 1970s coal boom, they find losses in non-traded jobs during the 1980s bust were even larger. Specifically, every ten additional coal jobs gained during the boom were associated with two additional jobs created in the local sector; but every ten coal jobs lost during the bust was correlated with 3.5 local sector jobs lost. Deaton and Niman (2012) use decennial census data to analyze the effect of coal mining employment on poverty rates in Appalachia. They found increases in contemporaneous mining employment reduce poverty. However, higher levels of mining employment ten years prior were associated with higher poverty rates and the effect was stronger than the contemporaneous effect, consistent with a resource curse explanation. Partridge et al. (2013), using data encompassing the entire U.S., found the association between coal mining and poverty was stronger in Appalachia than the rest of the nation. This association was also stronger in the low-price coal period of the 1990s than in the post-2000 decade of higher prices.

Other subnational studies find natural resource extraction in general retards economic growth, consistent with findings from the international development literature (Corden, 1984; Sachs and Warner, 1995, 2001; Van der Ploeg, 2011). These studies attempt to identify the channels through which such a process may occur. Using state-level data, Papyrakis and Gerlagh (2007) find that growth in Gross State Product (GSP) over 1986–2001 is significantly and negatively correlated with the initial share of the primary sector in GSP. Nearly all of this negative relationship between primary sector share and GSP is attributable to differences in education, R&D investment, market openness, and corruption. Similarly, Freeman (2009) finds agriculture and mining employment is significantly and negatively correlated with GSP. James and Aadland (2011) find that the county share of primary sector earnings is negatively correlated with annual growth in per capita income, further suggesting the negative effects of natural resource extraction operate at a sub-state level. Looking over the long-term from 1980–2011, Haggerty et al. (2014) found that the oil and gas boom of the 1980s had negative long-term effects on income growth and on other indicators of social wellbeing.

Subnational studies also provide some evidence that natural resource extraction negatively affects broader societal outcomes beyond income and employment that influence economies over the long term (Haggerty et al., 2014). Black et al. (2002) find that in Appalachian states affected by the coal boom and bust of the 1970s and 1980s, disability enrollments fell in the booms and rose in the bust. Black et al. (2003), using the same instruments, find welfare program expenditures are correlated with coal boom and busts. Black et al. (2005b) also find that local educational attainment falls during coal booms, which in turn may reduce long-term economic growth.

In sum, while some recent studies exist, a number of gaps remain. Coal has been less scrutinized than oil and gas and particularly so considering how it performs relative to those sectors. The natural resource curse and its application to Appalachia remains a source of debate. Research is in need of methodological updates that include modeling the non-random location of mining. Past studies are limited in scope and typically do not span the entire country. Finally, only a handful of economic outcome indicators have been examined. Few studies trace gains or losses for an array of different economic groups *within* communities such as local entrepreneurs, the middle class, different occupational segments, and the disabled. Our study provides a novel contribution to research on the economic impacts of natural resource extraction by filling these gaps.

3. Recent coal industry trends

During the 1990s and post-2000 periods of our analytical focus, the coal industry experienced several major transformative events. Fig. 1 shows the general decline of coal employment since 1948 starting with the rapid decline due to labor saving technological change that primarily reduced employment by nearly 75% by 1970. With the 1970s coal boom period identified by Black et al. (2005a), employment rose by 74% between 1970–1980 (from a smaller 1970 base). Then with the 1980s bust, industry employment fell 42% and another 47% during the 1990s.

Data are not strictly comparable between the pre- and post-2000 periods due to different sources in which the pre-2001 U.S. Bureau of Economic Analysis (BEA) data includes proprietors, and the U.S. Bureau of Labor Statistics (BLS) data only include wage and salary workers after 2000. The BLS data also include coal industry support workers, miniscule in 2001 but rising thereafter. Summing the two coal sectors' employment, total coal employment was up 14% between 2001 and 2010, consistent with a marked turnaround for the industry especially given the ongoing technological change that reduces employment.

Real coal prices over the 1970–2010 period are shown in Fig. 2. The coal boom of the 1970s and the bust of the 1980s identified by Black et al. (2005a) are apparent. Consistent with declining employment, real coal prices continued to decline in the 1990s, falling 41%. Yet, real prices rose 68% between 2000–2010, likely a key reason for rising coal employment during the period. Thus price and employment trends both support the view that the 1990s was a "bust" period and 2000–2010 was a "boom" period. Nonetheless as noted, Appalachian coal regions particularly suffered after 1998, indicating that the region should be considered separately from the rest of the United States.[1]

4. Conceptual model

Energy development and booms can create relatively large economic shocks – especially in small rural settings. Such shocks can push the economy

[1] Appalachia varies from the rest of the country for many other reasons including different coal production technologies, a longer history of coal mining, and its historical economic deprivation.

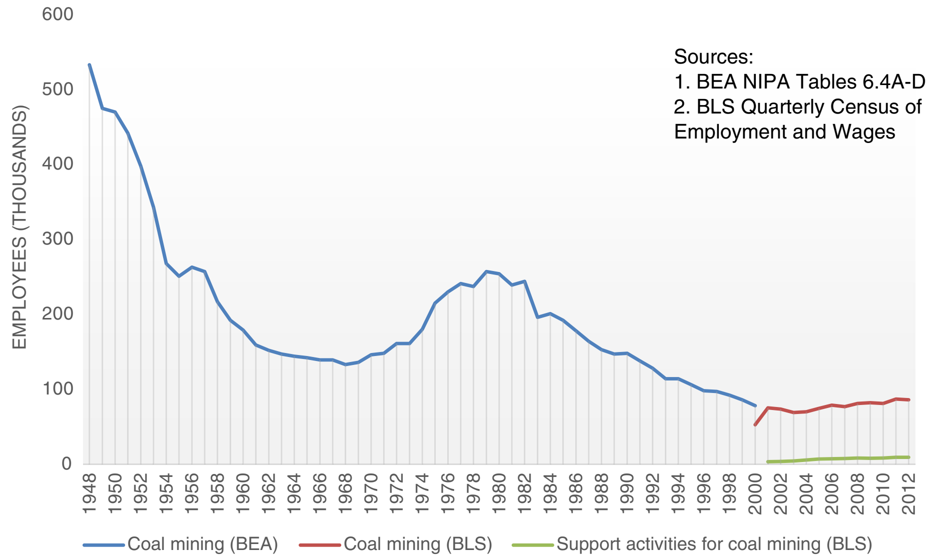

Fig. 1. Coal mining – employment (1948–2012).

past an agglomeration threshold or critical mass allowing growth to endogenously take-off. Perhaps the best known theoretical representation is the New Economic Geography models in which growth takes off due to increased variety and stronger input-output linkages (Krugman, 1991). Houston, Texas may be a good example for the oil industry as it added supply chain and higher-level corporate functions. Yet, the typical coal mining or oil patch town is small, suggesting that a spatial equilibrium framework is more appropriate in this general case, in which growth does not permanently remain above that of the pre-boom period because agglomeration thresholds are unlikely to be crossed.

The spatial equilibrium framework suggests that equilibrium profits and utility levels are equalized across space (Glaeser, 2007; Partridge et al., 2008). Firm profits π_i in location i are negatively related to the representative wage w_i and land costs (rents) r_i. Site specific amenities s_i may positively or negatively affect firm profits. When a location i experiences a positive (negative) economic shock, economic profits are greater (less) than the national average, attracting new (losing existing) firms, while wages and rents begin to increase:

$$\Delta \text{firms} = f(\pi_i - \pi_{avg}),\ f' > 0. \quad (1)$$

Households in i maximize their indirect utility function $V(w_i, r_i, s_i)$, which is positively related to wages w_i, inversely related to housing

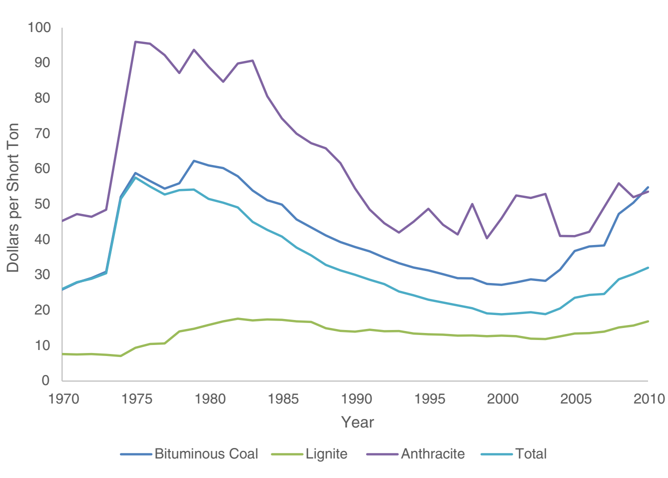

Fig. 2. Real coal prices 1970–2010. Source: U.S. Energy Information Agency.

costs (rents) r_i, and positively related to site specific amenities s that affect quality of life (or negatively related to disamenities). When a location i experiences a positive economic shock that increases its wages and rents, household utility initially rises above the national average V_{avg} and new workers are attracted by higher real wages. This process is represented by:

$$NetMig_i = g(V_i - V_{avg}),\ g' > 0. \quad (2)$$

The mechanism restoring equilibrium is higher wages and rising land costs (as people move in) that reduce profits on the firm side, while *real* wages eventually decline on the household side with rising housing costs. Households may be negatively impacted even further if quality of life declines due to greater congestion; and firms may be affected if other local institutional factors are altered. Once spatial equilibrium is restored, location i grows at the national average rate.

In an energy boom, wages and housing costs begin to rise as energy-related industries need to attract new workers, beginning the process just described. Factor prices and housing prices get bid up, slowing down employment growth and the higher housing prices eventually stem migration as household utility and profits return to the national average. In the short to medium term, the location experiences an increase in employment and population.

Factors associated with the natural resource curse can potentially affect the longer-term growth process. For example, energy booms may lead to environmental degradation and crowding that reduce quality of life. Likewise the quality of the local government may decline: this may occur, for example, if the local government overbuilds infrastructure or is captured by the industry in terms of its decision-making. Poor local government could reduce profits for the typical firm and further reduce quality of life. Conversely, as the location attracts people, it gains the benefit of agglomeration economies as industries gain critical mass. This would allow the location to reach a greater long-run equilibrium level of population and employment (Michaels, 2011). Hence, it is an empirical question as to whether the long-run effects of energy development are growth-inducing or growth-reducing (consistent with a resources curse interpretation), but the short-run growth-inducing effects appear theoretically clear, though there will likely be winners and losers across the regions and within regions. The opposite applies to a region facing declines in energy development such as from a coal mine closure.

Several factors may slow the adjustment process or prevent spatial equilibrium from occurring. First, individuals may have imperfect information about potential alternatives, preventing utility-enhancing moves. This may occur extensively in isolated rural areas where coal mining typically occurs. Secondly, individuals may lack the resources to relocate and credit market imperfections may prevent individuals from moving to places that would offer higher long-term utility. In terms of our study, if there are barriers to mobility, families may remain in depressed coal mining regions, creating even higher unemployment, further depressing wages, and increasing poverty rates.

5. Empirical implementation and data

We investigate how the intensity of coal mining affects different aspects of a locale's economic structure. Continental U.S. counties are our unit of observation. Coal employment's share of total employment in the beginning period is our measure of initial coal intensity. The analyses reported in the tables focus on two time periods: the 1990–2000 period in which coal prices were low; and the 2000–2010 period when coal prices were higher. In addition, we summarize results for 1990–2010 to investigate the long term effects of coal. For each time period, we separate counties within the Appalachian Regional Commission's (ARC) borders from those in the rest of the United States to assess whether coal mining affects outcomes differently in Appalachia.

Each economic outcome is a function of the county's economic, demographic, and spatial characteristics. Our empirical models take the form:

$$OUTCOME = \beta_0 + \beta_1 INDUS + \beta_2 DISTANCE + \beta_3 AGGLOM + \beta_4 DEMOG + \sigma_{ij} + \varepsilon_{ij} \quad (3)$$

where *OUTCOME* is a set of economic outcomes that may be affected by coal mining. We discuss the full list of dependent variables with detailed explanations and their sources below.

Our dependent variables for the decadal models (1990–2000 and 2000–2010) include percent changes in per capita income, wage and salary income, median household income, rental and investment income, population, accommodation employment, and retail employment. We also use level-measures of poverty rate, employment/population ratio, disability/employment ratio, and proprietors' share of total employment. The long-term models (1990–2010) employ the same set of dependent variables, except we use differences for the level-variables (i.e. poverty, employment/population, disability/employment, proprietors share). Per capita income, wage and salary income, proprietors' share of total employment, population, and rental income per capita are from the Bureau of Economics Regional Data. Poverty and median household income measures are from the U.S. Census Bureau's Small Area Income and Poverty Estimates (SAIPE). Population and demographic indicators are drawn from the US Census Bureau's 1990 and 2000 decennial censuses and the 2010 American Community Survey 5-year estimates. Disability indicators are from the Social Security Administration's Old Age, Survivors, and Disability Insurance Program (OASDI).

The explanatory variables are generally measured in the initial period in order to mitigate problems of endogeneity. The *INDUS* vector contains measures of the county's industrial structure, including initial mining industry employment shares and a measure of relative demand shocks. We include mining sector employment for coal, oil and natural gas, and other mining sectors; this allows us to draw broad comparisons across mining sectors. Employment data are from a proprietary dataset purchased from Economic Modeling Specialists International (EMSI) and include annual data between 1990 and 2010. The advantage of EMSI data is that employment data is disaggregated by 4-digit North American Industry Classification System (NAICS) industries. For our study, this has the benefit of distinguishing coal mining employment from other types of mining, such as oil and gas drilling, gravel mining, or metal mining, that are aggregated together in NAICS one-digit industry codes. Previous studies typically rely on one-digit industry mining data, possibly confounding the effects of coal mining with other mining types.

We create the total county coal mining employment share by dividing each county's coal mining employment by total county employment. We use the coal employment share because we want a measure of "dependence" that accounts for how much the labor market is influenced by coal mining and this is directly picked up by its employment share.[2] Employment share of oil and gas mining and all other mining are also included in our models. Mining support employment is a separate industry at the 4-digit NAICS level, however the category does not distinguish between support for coal mining, oil and gas mining, or other mining. We add mining support employment to each mining share by multiplying the number of county workers in mining support by the national share of mining support from each mining industry as reported by the Bureau of Labor Statistics.[3]

The demand shock variable is the predicted employment growth if all of the county's industries grew at their respective national growth rate, forming the industry mix term from shift share analysis.[4] The industry mix term is an exogenous measure of demand to account for shocks that may be correlated with initial coal employment. The term is often used as an exogenous instrumental variable in predicting local employment growth dating back to Bartik (1991).

A key economic control variable is the 1960 poverty rate provided by the USDA Economic Research Service. This 1960 poverty rate measure accounts for legacy effects that persist through our periods of analysis, effects that would include issues of governance, public service delivery, industry composition, and culture. The 1960 poverty rate variable captures legacy effects of poverty to control for the extent to which coal mining itself is associated with historical poverty rates. Thus, our coal employment share coefficients capture the more contemporaneous effects of coal mining and would not reflect these (net) positive or negative legacy effects.

The *DISTANCE* vector contains distance to the nearest metropolitan statistical area (MSA), the weighted average poverty rate of adjacent counties, and incremental distances to the nearest MSAs with populations of 250,000, 500,000, and 1 million.[5] Most coal mining occurs in remote rural areas and proximity to densely populated urban areas has been shown to be an important positive factor in rural economic growth and poverty (Partridge and Rickman, 2008).[6]

Agglomeration influences economic development and growth though: better employer-employee matching; dispersing infrastructure costs through input sharing; and knowledge spillovers. We account for

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[2] Alternatively, we could have used coal production as our measure of coal intensity but such a variable would introduce problems in our case. First, rising coal productivity means that a given level of production would be associated with differing amounts of workers over time. For example, there could be higher production in 2000 compared to 1990, even though employment has fallen due to productivity growth. Likewise, differing capital vintages or differing mining techniques such as strip- or underground-mining would also lead to differing amounts of workers for a given level of production.

[3] For instance, in 2010 the share of mining support employment devoted to coal mining support at the national level was 3%; if a county had 700 mining support workers, we added 21 workers (700 x 0.03 = 21) to that county's coal employment totals.

[4] The specific term is the industry mix term from shift-share analysis – i.e., the sum over all industries of the product of the initial period county employment share in the industry and the national growth rate in the industry over the relevant period. We use four-digit industry level in its calculation as provided by EMSI.

[5] See Partridge and Rickman (2008) for details of the incremental distance variables.

[6] We tested each of the 11 dependent variables we consider for spatial autocorrelation in each of our four samples (1990s and 2000s; Appalachian region and Rest of the US), resulting in 44 tests. In only three of the tests did we fail to reject a Moran's I value significantly different from zero at the 5% level. We repeated the tests using several specifications of the weighting matrix (contiguity and inverse distances truncated at 100, 200, and 300 miles respectively), but there were not meaningful differences by choice of weighting matrix. We then estimated SAR models for each of our specifications. Our original results did not display much sensitivity to the inclusion of the spatial term. We paid particular attention to the models in which the Moran's I tests suggested spatial autocorrelation. In those three models, the statistical significance of the coal variables did not change and the magnitude of their coefficients only varied slightly. This finding should not be surprising as the IV approach we incorporate should mitigate any endogeneity bias from omitted variables such as possible spatial regressive effects.

Table 1
Determinants of income, wage, and median household income growth.

	Percent change in per capita income				Percent change in wage and salary income				Percent change in median household income			
	1990–2000		2000–2010		1990–2000		2000–2010		1990–2000		2000–2010	
	US	ARC	US	ARC	US	ARC	US	ARC	US	ARC	US	ARC
1960 Poverty rate	0.44***	0.30***	0.13**	0.15*	1.40***	1.51***	0.54***	0.18	0.38***	0.36***	0.18***	0.20***
	(10.41)	(3.49)	(2.35)	(1.76)	(8.31)	(4.35)	(6.68)	(0.87)	(11.51)	(4.27)	(7.82)	(3.24)
Initial share coal employ.	−0.42	−0.39	0.79	2.15***	−5.23***	−2.44***	0.84	−0.28	−0.35	−0.99***	1.29***	1.80***
	(−1.29)	(−1.25)	(1.60)	(3.36)	(−3.49)	(−2.84)	(0.64)	(−0.19)	(−1.37)	(−3.27)	(3.24)	(3.66)
Initial share oil and gas employ.	0.34***	−0.01	0.52**	−0.36	−0.99***	−1.04	0.98**	−0.20	−0.49***	−0.10	0.72***	0.42*
	(2.84)	(−0.05)	(2.57)	(−0.85)	(−3.00)	(−1.05)	(2.12)	(−0.18)	(−4.86)	(−0.36)	(6.64)	(1.65)
Initial share other mining employ.	0.06	1.31*	0.15	−0.10	−0.82	−2.07	−0.61	−1.44	−0.06	−0.32	0.04	0.10
	(0.52)	(1.81)	(0.67)	(−0.16)	(−1.46)	(−0.95)	(−1.50)	(−1.23)	(−0.53)	(−0.63)	(0.42)	(0.24)
Observations	2602	417	2602	417	2602	417	2602	417	2602	417	2602	417
R-squared	0.314	0.403	0.502	0.517	0.205	0.536	0.422	0.490	0.446	0.428	0.595	0.645
First-stage F-test of instrument	46.25	37.85	35.09	24.21	46.25	37.85	35.09	24.21	46.25	37.85	35.09	24.21

t-statistics in parenthesis * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
See text for additional variables included in the models.

such affects with the *AGGLOM* vector, which contains measures of the nearest MSA population, total county population, MSA population, nonmetro population, and dummy variables controlling for whether the county is a core-city big MSA, core-city small MSA, suburban big MSA, or suburban small MSA following Partridge and Rickman (2008). Demographic factors affect economic outcomes primarily through human capital development, where places that have better educated workforces and higher proportions of working-age population tend to have better economic outcomes. Thus, the *DEMOG* vector contains measures of county age structure, education, race, place of birth, and family structure. By controlling for these additional variables, we seek to control for factors associated with coal mining that also in turn could affect economic outcomes, which along with our IV approach should mitigate or eliminate any endogeneity. The coefficients $\beta_1 - \beta_4$ are vectors of regression coefficients, σ_{ij} are state fixed effects of state i in time j, and ε_{ij} is the error term.

One of our concerns in estimating the models is the potentially endogenous relationship between coal mining employment and our outcome variables. If unobserved factors related to coal mining affect the outcome variables, our estimates may be biased. This may be the case if the coal industry targets places with dysfunctional or nonexistent regulatory structures, or alternatively is welcomed by pro-business counties. In such a situation, we cannot observe government quality, so if coal mining takes place in locations with dysfunctional government (for example), and such government drives out other types of economic activity, our estimates will suggest that coal mining has a more negative effect on economic outcomes than is actually the case. Conversely, if the coal industry predominantly locates in places with well-functioning business-friendly policies and such policies are attracting other businesses, then our results would be more positive than the true coal mining effect. Using Ordinary Least Squares (OLS) to estimate our models under such circumstances may lead to biased results.

To accommodate the existence of potentially important unobserved effects, we first use the industry mix term to account for demand shocks that may be correlated with coal mining shares *and* we also employ instrumental variables (IV) techniques. As potential instruments, we use geological data from the United States Energy Information Agency (EIA) to create a set of suitable instruments that should be correlated with initial coal mining intensity but only indirectly affect economic outcomes through their relationship to coal mining employment.[7] We tested several geological measures of coal quality and availability and respectively found that the 1990 and 2000 county average of the BTUs produced per ton of ash created was the best predictor of its coal mining employment share for the respective time periods. The industry desires coal that produces higher BTUs with the least amount of ash (average county BTUs per ton of ash), which is federally regulated. Below we test the robustness of our assumptions about the geological instruments.

6. Results

The results of our analyses are presented in Tables 1–4. Each table follows the same format. Results are presented for dependent variables respectively for the 1990–2000 and 2000–2010 periods and for both the ARC region and the rest of the U.S. Instrumental variables are used in all specifications. The first stage F-test of significance produces values are in the 24 to 46 range for the instrument (BTUs per ton of ash), suggesting that the geological instrument is strong.

6.1. Income distribution effects and coal

We first determine whether mining employment is associated with changes in per capita income and if so, whether the changes are primarily through changes in average county wage rates that would suggest a more egalitarian impact. Table 1 presents the results for models of the percent changes in per capita income, wage and salary income, and median household income. Coal's initial share of total employment is not statistically associated with changes in per capita income from 1990–2000 in both the ARC region and the rest of the U.S. The absence of an effect from the initial coal employment share is persistent across the U.S. post-2000. However this is not the case for the ARC region: here the initial coal share is positively associated with the percent change in per capita income after 2000.

The middle portion of Table 1 shows how coal employment levels and changes are related to wage and salary income. Focusing on wage and salary income alone is important because along with rising inequality, the share of wages and salaries in personal income has been declining, where the latter also includes among other things, profits, dividends, and interest.[8] In many cases, higher wages and salaries may reduce profits, dividends, and interest, which would affect income distribution and possibly producing different effects than wage

[7] For example, our assumption is that average BTUs in the coal underground only affects average wages by affecting coal mining intensity as measured by the initial coal mining employment share. Our maintained assumption is that the initial geology is exogenous to future production. See Angrist and Pischke (2009) for more discussion of instruments. The data for our instruments are from USEIA's annual Federal Energy Regulatory Commission 423, which contain data for each coal plant concerning quantity, quality, and source of coal used in electricity production.

[8] In 1969, U.S. wages and salaries accounted for 64.8% of personal income, before respectively falling to in 50.8%, 55.9% and 51.3% 1990, 2000, and 2010. For the coal mining state of West Virginia, the respective 1969, 1990, 2000, and 2010 wage and salary shares equal: 67.4%, 50.8%, 48.2%, and 51.3%.

Table 2
Determinants of changes in poverty rate and retail income and employment/population ratio level.

	Change in Poverty Rate				Percent Change in Rental Income				Employment/Population Ratio			
	1990–2000		2000–2010		1990–2000		2000–2010		1990–2000		2000–2010	
	US	ARC	US	ARC	US	ARC	US	ARC	US	ARC	US	ARC
1960 Poverty rate	0.04***	0.07***	0.03***	0.04*	−0.00	−0.00	−0.00	0.00	−2.5e-03***	−3.3e-03***	−2.2e-03***	−2.2e-03**
	(4.36)	(2.78)	(3.15)	(1.84)	(−0.41)	(−0.82)	(−0.21)	(0.17)	(−7.78)	(−4.60)	(−5.36)	(−2.46)
Initial share coal employ.	−0.08	0.21**	−0.19*	−0.04	0.01	0.04**	0.04	0.06*	1.0e-03	2.2e-03	1.0e-02**	8.7e-03
	(−1.22)	(2.53)	(−1.84)	(−0.24)	(0.42)	(1.96)	(0.51)	(1.72)	(0.38)	(0.86)	(2.17)	(1.42)
Initial share oil and gas employ.	0.02	0.15***	−0.14***	0.13*	0.03***	0.01	0.05***	−0.00	5.2e-04	−2.1e-05	8.7e-03***	7.6e-03**
	(0.66)	(2.63)	(−3.88)	(1.66)	(3.21)	(1.16)	(2.60)	(−0.1)	(0.57)	(−0.01)	(3.75)	(2.51)
Initial share other mining employ.	−0.01	−0.21	−0.05**	−0.24**	−0.03***	0.01	−0.1***	0.01	−2.3e-03**	−4.5e-03	−1.4e-03	−7.2e-03
	(−0.49)	(−1.50)	(−2.23)	(−1.96)	(−2.92)	(0.36)	(−2.96)	(0.09)	(−2.12)	(−0.93)	(−1.24)	(−1.29)
Observations	2602	417	2602	417	2602	417	2602	417	2602	417	2602	417
R-squared	0.862	0.883	0.843	0.838	0.675	0.784	0.679	0.795	0.492	0.601	0.492	0.506
First-stage F-test of instrument	46.25	37.85	35.09	24.21	46.25	37.85	35.09	24.21	46.25	37.85	35.09	24.21

t-statistics in parenthesis * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
See text for additional variables included in the models.

Table 3
Determinants of disability/employment ratio and percent changes in population and accommodation employment.

	Disability/Employment Ratio				Percent Change in Population				Percent Change in Accommodation Employment			
	1990–2000		2000–2010		1990–2000		2000–2010		1990–2000		2000–2010	
	US	ARC	US	ARC	US	ARC	US	ARC	US	ARC	US	ARC
1960 Poverty rate	4.7e-04***	3.4e-04	5.1e-04***	4.0e-04	0.52***	0.48***	0.31***	0.18***	0.27	1.76*	0.73***	0.86
	(8.54)	(1.28)	(6.63)	(1.21)	(13.24)	(5.62)	(10.84)	(2.62)	(0.20)	(1.85)	(4.11)	(0.92)
Initial share coal employ.	8.1e-05	2.6e-03**	−1.4e-03	2.4e-03	−0.58**	−0.84***	−0.21	−0.70**	−6.89	−1.35	−3.00*	−6.92
	(0.23)	(2.51)	(−1.49)	(0.89)	(−2.19)	(−3.36)	(−0.69)	(−2.11)	(−1.39)	(−0.82)	(−1.88)	(−1.22)
Initial share oil and gas employ.	2.8e-04**	6.2e-04	−8.9e-04***	−1.4e-3	-0.39***	−0.24	0.16*	−0.12	−4.52	−0.79	1.36**	−3.18
	(2.19)	(0.66)	(−3.40)	(−0.90)	(−4.35)	(−1.18)	(1.70)	(−0.50)	(−1.59)	(−0.62)	(2.13)	(−1.16)
Initial share other mining employ.	7.2e-04***	1.7e-03	1.4e-03**	3.4e-04	−0.29**	0.23	−0.35***	−0.51	−3.64	−7.21	−0.06	−2.92
	(2.69)	(0.96)	(2.44)	(0.16)	(−2.27)	(0.34)	(−3.61)	(−1.10)	(−1.02)	(−1.31)	(−0.10)	(−1.16)
Observations	2602	417	2602	417	2602	417	2602	417	2602	417	2602	417
R-squared	0.674	0.769	0.706	0.738	0.604	0.703	0.565	0.706	0.054	0.262	0.100	0.044
First-stage F-test of instrument	46.25	37.85	35.09	24.21	46.25	37.85	35.09	24.21	46.25	37.85	35.09	24.21

t-statistics in parenthesis * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
See text for additional variables included in the models.

Table 4
Determinants of percent change in retail employment and proprietors share of total employment.

	Percent Change in Retail Employment				Proprietors Share of Total Employment			
	1990–2000		2000–2010		1990–2000		2000–2010	
	US	ARC	US	ARC	US	ARC	US	ARC
1960 Poverty rate	0.95***	1.49***	0.43***	0.30*	0.24***	0.31***	0.19***	0.18**
	(8.44)	(3.07)	(6.88)	(1.91)	(12.28)	(5.58)	(7.96)	(2.37)
Initial share coal employ.	−0.95	−0.92	−0.85	−1.78*	−0.37**	−0.38**	−1.72***	−2.21***
	(−1.46)	(−1.13)	(−1.35)	(−1.96)	(−2.34)	(−2.15)	(−4.98)	(−4.29)
Initial share oil and gas employ.	0.13	0.91	0.49**	0.02	0.29***	0.59***	−0.03	−0.06
	(0.31)	(0.82)	(2.09)	(0.04)	(5.23)	(3.25)	(−0.34)	(−0.21)
Initial share other mining employ.	0.62	−4.69	−0.29	−0.86	−0.03	0.15	−0.07	−0.08
	(1.06)	(−1.56)	(−1.25)	(−0.97)	(−0.51)	(0.34)	(−0.63)	(−0.09)
Observations	2602	417	2602	417	2602	417	2602	417
R-squared	0.189	0.387	0.219	0.394	0.509	0.510	0.491	0.350
First-stage F-test of instrument	46.25	37.85	35.09	24.21	46.25	37.85	35.09	24.21

t-statistics in parenthesis * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
See text for additional variables included in the models.

and salary income alone. For both the rest of the U.S. and ARC samples, higher initial coal employment shares are negatively related to wage and salary growth in the 1990s, but statistically insignificant post 2000. Thus, it is not clear whether any of the broader positive personal income effect associated with a rebound in coal prices in the ARC region post-2000 is from higher regional wages.

We next determine the manner by which changes in coal employment affect households at different points in the income distribution. The right side of Table 1 shows the determinants of changes in median household income. For example, if coal mining is associated with favoring those at the top of the distribution, a rising share of coal mining may reduce the median household income. Likewise, median household income varies from average wages as it is affected by labor force participation and the prevalence of two-earner households. Yet, we find no significant statistical association between the coal employment share and changes in median household income in the rest of the U.S. in the 1990–2000 period. In the ARC region, initial coal employment share is negative and highly statistically significant. Middle class households in the ARC region likely would have been hurt more during the low-price decade of the 1990s as fewer coal employment opportunities would have existed for laid-off coal workers. This association however is reversed post-2000, where initial coal employment is positively associated with median household incomes in both the ARC region and the rest of the U.S. This positive median income response may be due to multiplier effects to other local industries or by some direct employment effects of the industry due to higher coal prices. In sum, the high coal-price decade post-2000 seems to have benefitted middle class residents, although they had previously lost ground when coal prices were weak in the 1990s.

While middle class households seem to have benefitted in places with higher initial shares of coal employment post-2000, the results are mixed for low-income households. The left side of Table 2 shows results for the change in poverty rate. Initial coal employment shares are statistically insignificant for the rest of the United States from 1990–2000. But for the ARC region, the coefficient for the initial coal share in the ARC region is positive and statistically significant. However, post-2000, the initial coal employment share is statistically insignificant in the ARC model. Consistent with Partridge et al. (2013), this pattern suggests that either the high coal-price decade post-2000 dampened some of the poverty-inducing effects of coal mining or that other long-term, regional forces are weakening the poverty-increasing effects of coal mining in the ARC over time.

The middle columns of Table 2 present the results for rental/investment income. These models allow us to examine whether wealthier land/asset owners are impacted by coal employment through rental/investment income. In both decades, we find no evidence rental/investment income is related to the initial coal employment shares in the rest of the U.S. The ARC region differs, with the initial coal employment share being significantly related to higher rental/investment incomes in both the 1990–2000 and the 2000–2010 models. Thus ARC counties with high initial coal employment shares are associated with land/asset owners faring better in both decades, which might explain some of the previous income results in Table 1.

Overall our results suggest that coal intensity was related to a less egalitarian income distribution in the 1990s, especially in the ARC region. By contrast during the boom period after 2000, coal intensity was associated with a neutral or perhaps even more egalitarian distribution related to increased incomes at the middle of the distribution. These findings do not yield consistent conclusions about a potential natural resource curse in the ARC but rather suggest that over the longer period, coal intensity had mixed effects.

6.2. Labor market consequences: Do original residents benefit from changes in coal intensity?

Economists have long debated whether job growth benefits local residents – especially disadvantaged ones – or whether newly-created jobs go primarily to workers who have in-migrated or in-commuted in search of work. The answer is critical for understanding coal's local impact as to the degree to which expansions or contractions are felt locally. For example, Blanchard and Katz (1992) find that there is an almost one-for-one migration response to overall employment growth, suggesting original residents do not experience persistent employment benefits from job growth. Those results were challenged by Bartik (1993), who found about one-quarter of the new jobs went to original residents. More recently Partridge and Rickman (2006), Rowthorn and Glyn (2006), and others find that in the long-term (about 7 years), approximately 80% of the new jobs go to migrants, whereas 20% of the jobs go to original residents.

To address this question for coal, we present results for the employment/population ratio (emp/pop) in the right-side columns of Table 2. It should be kept in mind that the emp/pop ratio and the coal share variables are both measured in the same units (ratios), meaning that a regression coefficient of one indicates a one-for-one relationship between coal mining employment and the emp/pop ratio. For the rest of the U.S., there is no statistically significant relationship between the initial 1990 coal mining share and the 2000 emp/pop rate, however there is a statistically significant positive relationship for the 2000 coal employment share and the 2010 emp/pop rate. But the economic significance of the latter relationship is small. A one percentage point higher 2000 coal employment share is associated with a 0.01 higher emp/pop rate suggesting a limited positive effect for the overall local labor force. The small regression coefficient suggests that most of the jobs go to outside commuters and new residents, or that they are reallocated to local workers who switched sectors. The ARC results suggest an even weaker emp/pop response in which the coal mining share has no statistically significant effect in both decades. Thus, while some individuals are benefiting from the new employment opportunities, it is not clear that they are the original resident workforce. The ARC results suggest that a transient workforce moves in and out of Appalachian coal towns in booms and busts (Black et al., 2005a).

6.3. Labor-market consequences: The disabled population

To further examine the labor market consequences of coal, Table 3 reports results for models where the 2000 and 2010 ratios of the disabled to total employed are the dependent variables. Certainly coal mining (especially underground mining) is a dangerous vocation with consequences such as black lung disease that can spur individuals to go onto disability or to permanently exit the labor force. To the extent that coal mining intensity increases disability, it reduces labor market flexibility. Moreover, disability entails costly social programs. For the rest of the U.S. in both decades, coal mining has no statistically significant association with the disability/employment ratio. In Appalachia during the 1990s, a larger initial coal employment share is associated with a higher disability ratio, but it is not statistically significant in the post-2000 model. While future research is needed to more fully flush out these findings, it appears that the demographic composition of the workforce itself increasingly drives disability rather than the intensity of coal mining.[9] Yet, we caution that our findings may just reflect a temporary pattern, as factors such as black lung disease, which had been almost entirely eliminated in the late 1990s is now back at rates last seen in the 1970s (Blackley et al., 2014).

6.4. Population growth and coal

To further examine who benefits from the size and growth of the coal industry, the middle columns of Table 3 present results for the *percentage change* in population. For both the U.S. and ARC, population

[9] A reviewer insightfully noted that the higher risk of injury and death in coal mining may strengthen community and workplace ties, making people more reluctant to leave when there are down times and thus more likely to claim disability.

growth is strongly inversely associated with the initial 1990 coal employment share. Since the coal industry was generally in decline in the 1990s, these results suggest that people were fleeing places with a high-intensity of coal production. The 2000–2010 population growth models show that the initial coal employment share is no longer statistically significant for the rest of the US, though it remains negative in direction. This change may relate to the relatively stronger market for coal during the decade. Likewise, regulatory changes and better reclamation practices may have reduced some of the undesirable negative externalities associated with coal mining in the post-2000 period. Despite the strength of the coal market, ARC locations with greater initial 2000 coal employment shares continued to suffer statistically significant population losses, though the effect is slightly less than in the 1990s.

Our results for population growth in conjunction with those for emp/pop (from Table 2) have key implications for labor market processes. The 1990–2000 population results suggest that residents of coal intensive places either do not wish to remain in those locations – perhaps due to the negative externalities associated with coal or to views that the long-run prospects in coal mining communities are bleak.[10] Likewise, the negative association between coal mining and population change in the 1990s, as well as the small association between coal mining and emp/pop rates, suggest that changes in coal mining employment were almost identically offset by changes in commuting and employment in other local sectors. This suggests coal was not an economic engine of growth in the 1990s, especially in Appalachia. Between 2000 and 2010, this pattern modestly reversed for the rest of the U.S., as a larger local coal industry is associated with higher emp/pop; however for Appalachia, the patterns of the 1990s continued, though possibly in a weakened form. One possible reason for the different labor market response may be that ARC coal country residents believed the prosperity of the coal industry in the 2000–10 period to be temporary given the industry's long-term, protracted employment decline.

6.5. Coal's relationship to other local industries and entrepreneurship

A common but under-researched question is the degree to which coal mining influences other local industries. For example, one of the hypothesized channels through which the natural resource curse operates is by crowding out other productive activities or industries. Alternatively, mining jobs create employment multipliers that increase employment in unrelated industries, such as retail, through the income spent locally by coal workers. We examine whether initial coal employment share is correlated with the percent change in tourism/accommodation employment (NAICS sector 72) or retail employment (NAICS sectors 44–45) to assess these effects. Coal mining is environmentally invasive and may discourage outdoor recreational and tourist activity, while relatively high-paying mining jobs could support local retail.

Results from the left columns of Table 3 show no statistically significant relationships between the coal employment share and changes in accommodation employment for both the rest of the US and ARC region during the 1990s. Post-2000, there is a statistically significant negative relationship between percent change in accommodation employment and the initial coal employment share in the rest of the U.S., but this remains insignificant in the ARC sample. For the rest of the U.S., this may suggest that tourists avoid places where coal mining is prevalent or that the more prosperous (post-2000) coal mining industry crowded out accommodation employment. It is unclear, however, why this relationship does not apply for the ARC region, although one reason may be that its coal communities have a relatively small tourist industry to begin with.[11]

The change in retail employment results are presented in the left columns of Table 4. They show that initial coal employment share is not significant in the 1990–2000 models for the U.S. and the ARC region. For the 2000–2010 models, the initial coal employment share remains statistically insignificant for the rest of the U.S., but for the ARC region, the initial coal employment share is inversely associated with retail employment growth. Overall, coal employment is not associated with retail employment in the U.S., suggesting little evidence coal is crowding out jobs in other local sectors. The negative association found for the ARC may be related to wide-spread population declines in places where coal mining is prevalent and positive multiplier effects may be modest.

Finally in unreported results, we examined manufacturing employment growth because another possible natural resource curse avenue is that mining booms increase wages that make local traded goods production less competitive. We found no statistical relationship between manufacturing employment growth and coal employment in any of the US and ARC models, suggesting that on net, coal neither crowds out nor stimulates (on net) local manufacturing.[12]

Mining can affect other dimensions in the underlying business climate such as affecting the role of small business formation and entrepreneurship. The link between entrepreneurship and economic growth is intuitive, as entrepreneurs are innovative risk-takers and create employment opportunities. For example, Chinitz (1961) famously compared New York's entrepreneurial garment industry to Pittsburgh's large corporate steel industry. More recently, this hypothesis has been supported in a number of empirical studies (Glaeser et al., 1992, 2010, 2012), as has the hypothesis that small business development supports local growth (Loveridge and Nizalov, 2007). Researchers use a number of proxies for entrepreneurship, including the rate of self-employment and proprietors. In the case of Appalachia, Stephens and Partridge (2011) find that the self-employment rate is positively associated with employment and income growth. Glaeser et al. (2012) find that close proximity to a coal mine in Appalachia crowds out entrepreneurship (as measured by self-employment rates), suggesting that coal mining intensity reduces the long-term growth prospects by crowding out entrepreneurs and small businesses. They argue that access to a large employer reduces individuals' willingness to start their own businesses.

Against this backdrop, the right columns of Table 4 present the results for the proprietor's share of total employment as the dependent variable.[13] The initial share of coal employment is negatively and significantly related to proprietors' share of total employment. The effect is also larger post-2000 for both the ARC and the rest of the US post-2000, suggesting a stronger "crowding-out" effect when higher coal prices persist, which would have possible negative implications for subsequent growth after the boom.[14] These results suggest one avenue by

[10] Another possible reinforcing factor is ongoing labor saving technological change in the coal industry.

[11] An anonymous reviewer suggested that we estimate models of residential real estate lessor employment growth and retail sporting goods store employment growth to get at other forms of tourism. We did so and found the initial coal employment share was statistically insignificant in all cases (results available on request).

[12] A reviewer suggested that we estimate models of construction and transportation employment growth to assess crowding out or positive multiplier effects. The only two initial coal-share coefficients that were statistically significant (both at the 5% level) were the 1990–2000 ARC transportation model which was negative and the 1990–2000 construction model for the rest of the U.S., which also was negative. These results suggest that for those two cases, either multiplier effects are modest or that the sectors were partially crowded-out and/or falling population hindered their growth.

[13] The self-employment data includes sole proprietors and partners (and directors) from, for example, LLCs and corporations. While self-employment is often used as a proxy for entrepreneurship in the literature, it has been criticized for possibly reflecting causal self-employment or other skills that are only weakly associated with entrepreneurship (Stephens and Partridge, 2011; Goetz and Rupasingha, 2014).

[14] The entrepreneurship literature points to a potential distinction between necessity and opportunity entrepreneurship (Ács and Varga, 2005). Necessity entrepreneurship is associated with people starting businesses due to a lack of job opportunities. Opportunity entrepreneurship is associated with people starting a business due to good ideas in either a product or in its production, in which opportunity entrepreneurship is often thought to have a larger effect (though it is hard to identify one type from the other). Our results cannot say which type of entrepreneur is being crowded out by coal mining. It could be necessity types because of more coal mining job opportunities or it could be opportunity types who are repelled from the areas intense with coal mining. Likewise, one reviewer suggested that underground mining in particular may be attracting risk-loving individuals, leaving fewer risk takers to start new businesses. Our study leaves open this question for future researchers to assess these possibilities.

which coal mining could foster a natural resource curse – by restraining entrepreneurial spirits and small business start-ups.[15]

6.6. Comparison to oil and gas and other mining

Oil and gas exploration and production are key energy industries and natural gas is a close competitor with coal. However, their local economic development implications differ from those of coal. Overall coal mining has more steady direct short- and long-term economic effects at a mine site. Oil and natural gas exploration have more variable impacts that start with a heavy construction phase of building rig sites, roads, and related infrastructure such as pipelines, which then greatly slows even as production remains quite high. Another feature is the potential for large lease and royalty payments to landowners; these payments could significantly increase per capita income in oil and natural gas regions, but they may not trickle down to raise local wages and median household incomes. To explain the results of our analyses, we summarize key similarities between coal and oil-natural gas treating common features of energy development and also note differences related to their distinct timelines of development.

It is not surprising that when considering the initial employment shares, oil and gas employment are more positively linked to higher per capita income growth than is coal employment for the rest of the U.S., given that oil and natural gas exploration is associated with large royalty and lease payments. Yet, surprisingly there is little statistical link between oil and natural gas intensity and income in the ARC region.[16] Likewise, the marginal response of wage and salary income to oil and gas employment is negative and statistically significant for the 1990s for the rest of the U.S. but insignificant in the ARC region. This changes to positive and statistically significant effect for the 2000–10 period for the rest of the U.S. but remains insignificant for the ARC region.

Compared to coal, there are some differences for how oil and gas employment share impacts changes in median household income and changes in poverty rates. The results suggest oil and gas mining did not have the negative effect on median household income that coal mining did in the 1990s and the ARC region missed out on some of the poverty-reducing effects of oil and gas post-2000. However, oil and gas had a positive and significant association with the emp/pop ratio in the ARC region post-2000, suggesting oil and gas may have had some benefit to local workers. Our findings weakly show that coal employment is more negatively associated with population growth relative to gas and oil. Unlike the negative association between coal mining and the proprietor employment share, the oil and gas share had a positive association in the 1990s and no significant association over the 2000–2010 period. Thus, it appears that oil and natural gas does not hurt small business development nor dampen entrepreneurship as appears to have occurred in the case of coal mining. In general, it seems the rest of the U.S. is experiencing benefits from a larger oil and gas sector post-2000, but the ARC region is not sharing in these benefits, possibly because the oil and gas sector is crowding out coal jobs.

6.7. Robustness to alternative instruments and identification

We noted that the 1990 or 2000 BTU quality of the coal provided a strong instrument, though a limitation is that we had to invoke the assumption that these geological measures are exogenous to the making of future production plans. We tested this assumption in a variety of ways by also including the following geological instruments: 1) the maximum BTUs per unit of sulfur in the county and 2) the lag 1990 values of our original geological instruments (average county BTUs per unit of ash) for the 2000–2010 models. We cannot lag the 1990 geological instruments because the geological data before 1990 was not reported in a consistent form. The results of this analysis for the 1990–2000 models suggested that using the BTU per ash and BTU per sulfur instruments together produced almost the same coal share regression coefficients, though in a small share of the cases, the significance changed (results available on request). Both instruments were jointly strong producing first-stage F-statistics for their strength of 27.4 for the entire U.S. (net of the ARC region) and 36.2 for the ARC model, though these are below values in our base models. One of the nice features of this approach is that we can use the Sargan over-identifying test when we have two instruments. In all of the specifications, we fail to reject the null hypothesis that the instruments are not exogenous at the 5% level, supporting our contention that our instruments are exogenous.

For the 2000–2010 models, we tried three different forms of robustness tests. First we used the lagged 1990 BTU per ash variable as the instrument. Second, we jointly used the 2000 BTU per ash and 2000 maximum BTU per sulfur variables and third, we repeat with both instruments but use the corresponding 1990 lagged values for both variables. Again, the results are very similar with a handful of cases where significance of the coal coefficient changed one-way or the other. The first-stage F-statistics ranged from 13 to 46, suggesting strong instruments but not quite as strong as our base models. Further, none of the Sargan over-identification tests could reject the null hypothesis of exogeneity at the 5% level, supporting our assumption that the geological instruments are exogenous.

6.8. Change in coal shares and production techniques

We perform additional robustness checks related to the timing and the production process. First, we assess whether our results hinge on whether the coal mining is underground or strip mining. We evaluate the effect of mining type by adding the share of coal mining production that was underground within the county (results available upon request). In every case, the underground share was statistically insignificant at the 5% level. Hence, we concluded that after controlling coal share and region (ARC and rest of the U.S.), there are no further effects from the specific production process.

Another question pertains to the extent to which the economic outcomes are affected by contemporaneous changes in coal employment. We address this question by including changes in the coal employment share to our previous models. The initial coal employment share may capture long-term cross-sectional effects, but contemporaneous changes may reflect short-term demand shifts. Thus, we examine models that include changes in employment shares, which are defined as the difference between the share in time $= 2$ and time $= 1$.[17] Changes in the

[15] We also examined whether coal mining is associated with the county's skill distribution by examining the percent of the adult population with at least a high school degree and the percent of the population with a college degree. Generally the coal results were statistically insignificant (not reported). The only exceptions were that the ARC high school graduate share is inversely associated with the coal share and the US college graduate share is inversely associated with the coal share during the 2000–2010 period. In general, we find only weak evidence that contemporary coal mining is associated with lower educational attainment.

[16] One concern about this comparison is that the location of oil and gas production may be endogenous like coal. Yet, there are reasons to believe that it is more exogenous, especially post 2000. Specifically, the advent of new hydraulic fracturing innovations that has driven growth in the oil and natural gas sector could not have been foreseen by residents and by potential residents. Thus, these results should be cautiously interpreted. Nevertheless, we tried to treat the oil and gas employment share as endogenous using the percent of the county that covers oil and gas shale resources, following Weber (2012) (results available on request). However, it was generally a weak instrument in our case. In those models, the coal share results were virtually unchanged, while the oil and gas coefficient became about 10 times larger in most cases and its statistical significance was typically lost. Thus, we did not pursue this approach further.

[17] For instance, the coal mining employment share of Raleigh County, WV was 6.0 in 1990 and 3.3 in 2000, so the change in the coal employment share was −2.7. Using changes in coal shares avoids the small base problem. For example, one can imagine a rural area with initially (say) 5 coal employees. Then after a major mine opening that employs 500, then the percent change would be 10,000%, while the change in coal shares would limit this impact to its actual change on the economy.

employment share of oil and gas mining and all other mining are also included. Unfortunately, our geologic instruments are weak predictors of the change in coal employment share and thus we only treat the initial coal employment share as endogenous (as before). Our maintained assumption is then that short-term changes in coal employment reflect exogenous shifts on the global market and factors such as regulatory shifts, but even so, the results should be cautiously interpreted. We briefly explain these results (see Appendix, Table 1).

The growth in per-capita income, wage and salary income, and median household income generally show that for the rest of the U.S. and the ARC region, changes in the coal employment share had little statistical influence in the 1990s, but these relationships became generally positive and statistically significant in the 2000–2010 period. Thus, there is some evidence that the post-2000 coal boom helped middle class coal community families, even if the long-run trends are not so clear. Yet, these effects did not reach down to lower-income households as reflected by the insignificant results for the poverty rate. This pattern was weakly reinforced for the rest of the U.S. during both periods, in which the change in the coal share is positively associated with emp/pop ratio, though it is not significant in the ARC emp/pop models.

The change in coal share had negative and statistically significant relationship with ARC population change in the 1990–2000 period, showing that even where coal fared well, people were inclined to leave, though this effect becomes insignificant in the latter period. For the rest of the U.S., after being insignificant for the 1990–2000 model, the change in coal share was positively related to population growth post 2000, further supporting the notion that the negative effects of coal mining were weaker in that decade. For the self-employment results, the change in coal share is negatively related to self-employment, statistically significant in three of four cases. These results further support our earlier observation that any natural resource curse may be related to reducing entrepreneurial capacity.

6.9. Long-term models: 1990–2010

To evaluate the robustness of our previous models and improve understanding of the long-term effects of coal mining, we estimate models that encompass the change from 1990–2010. These models are useful in assessing whether the long-term impacts of coal mining employment are obscured because we separate our analyses into the bust decade of the 1990s and the boom decade post-2000. The results are omitted to condense text but we summarize noteworthy trends. First, the initial share of coal mining appears to be associated with a more equal income distribution for the rest of the U.S. when considering growth in median household income and poverty rates over the entire 1990–2010 period, though it is significant for growth in per-capita income and wages and salaries. However, for the ARC region, there is no clear link between coal and the aforementioned outcomes except that growth in per-capita income and the change in the employment/population ratio are positively linked to the initial coal share at the 5% level. The initial coal mining share is strongly related to declining population in the ARC region, but not for the rest of the U.S.

Perhaps more importantly for long-run growth, the initial coal employment share is inversely associated with the share of self-employment in localities. Thus in the long-run, any natural resource curse effects of coal mining may be linked to lower entrepreneurship and reduced small business development. On this point, the results suggest that policymakers in the ARC region and coal-mining communities in general should redouble their efforts to promote entrepreneurial and small business support systems (i.e. youth exposure to this career path, better financing, market identification, mentoring, etc.) to help the region weather mining busts and diversify employment.

Overall, we do not detect clear resource-curse effects aside from the boom-bust effects often expected from the literature and explained above. The findings, however, raise interesting possibilities for a contemporary resource-curse effect that emerges indirectly through factors such as reduced entrepreneurship among local populations.

7. Conclusion

This study takes a new look at the impacts of coal employment. We respond to current gaps in research and address emerging concerns brought about by the global energy revolution and climate change regulations. A unique feature of this study is the use of novel instruments to account for unobservable factors that may bias the statistical association between coal mining and economic outcomes. We also examine the effects of coal mining employment on a wide range of economic indicators including those that have received scant empirical attention and where speculation as to the direction of effects remains. We address both the bust period of the 1990s and a boom period of 2000–2010 in order to assess the differential impacts across different points in the coal mining cycle. Effects in the Appalachian Regional Commission area are contrasted with the rest of the United States because coal mining in the ARC region has been often associated with negative economic outcomes.

In updating research on the coal industry to the present, we find that its largest effects tend to occur through its boom/bust features. Coal employment is generally associated with more positive (or less negative) effects in the post-2000 boom period relative to the 1990s and these results generally holding for both Appalachia and the rest of the U.S. Nonetheless, in both the boom and bust period, ARC counties tended to fare worse on economic indicators relative to other U.S. counties. Appalachia does not appear to be among the regional winners in the present energy revolution and the results suggest that climate change regulations that limit coal usage may have disproportionate negative effects on coal communities, at least in the short term.

Researchers continue to assess whether the natural resource curse remains applicable in modern economies. Extending this question to the subnational level, we do not find clear evidence of a resource curse across coal intensive communities today. However, our study indicates that future research is needed given the results for some indicators such as entrepreneurship and distributional measures in the case of Appalachia.

By analyzing a relatively extensive array of economic indicators, a unique aspect of our study is to identify not only variations *across* places, but also whether different population segments *within* places gain and lose. For the ARC region, coal mining does not appear to engender the same benefits to lower and middle-income households as it does in the rest of the United States. One explanation for this may be connected to the region's long-standing dependence on the coal industry. Coal industry interests may be stronger in the ARC region, leading to a larger proportion of benefits flowing to mine owners rather than mine workers and the local population, though variation in average worker skills is another explanation.

Finally, by assessing an array of indicators, our study contributes to a more nuanced understanding of the impacts of coal mining, documenting relationships beyond those examined in much previous research. For the ARC region, over the entirety of the boom/bust cycle, we find that coal employment is positively related to changes in per capita income and the employment-population ratio. But it is negatively associated with changes in population and measures of entrepreneurship as reflected by self-employment. An important implication is that although increased coal employment may have short-term aggregate employment benefits for remote Appalachian communities, it appears that higher coal employment shares are associated with deleterious long-run effects by driving out population and dampening entrepreneurship. Yet, the most consistent impact of coal intensity may be attributable to the boom/bust process where the industry transmits its cyclical effects on coal dependent communities.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.eneco.2015.04.005.

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