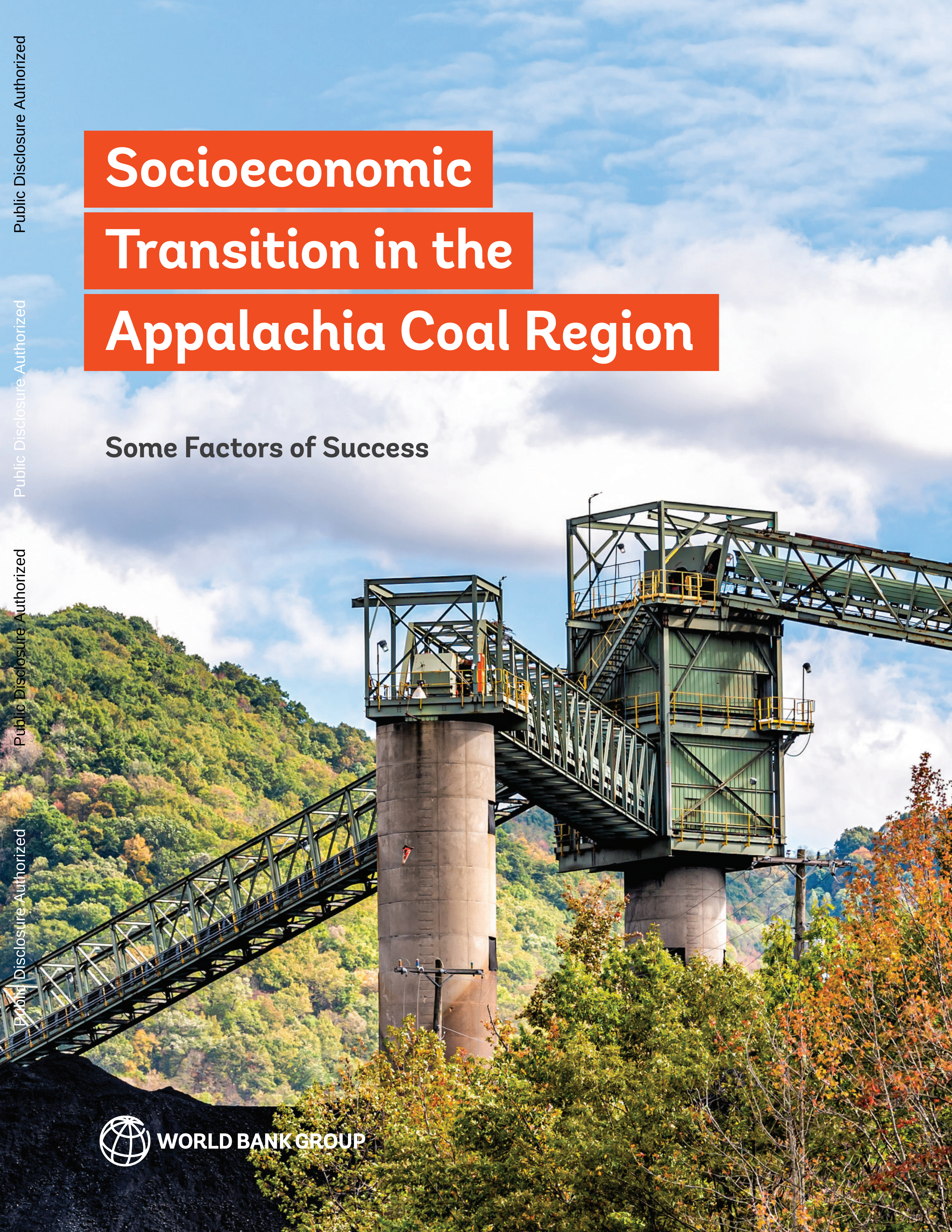
Socioeconomic Transition in the Appalachia Coal Region

Some Factors of Success



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Executive Summary

From the early 19th century, Appalachia was the primary U.S. coal producer, but over the course of the last century, its coal industry evolved and ultimately faded from market dominance. This transition took a very long time, and spanned periods of boom and bust, new mine openings and mine closures, as well as wide-ranging economic development unrelated to coal, all of which shaped coal sector employment in the region's coal communities. During the past 70 years, coal sector performance exhibited significant heterogeneity in the timing of coal-related business cycles and in spatial concentration. The 1950s and most of the 1960s saw the closure of many marginally-productive mines on the outer fringes of Appalachia, squeezed out by technology-aided competitors. Many Appalachian counties experienced a surge in coal employment during the 1970s, followed by mine closures during the "bust" years of the 1980s and during the 1990s with the tightening of environmental regulations.

Appalachia's reign as the principal coal region of the U.S. has considerably waned in recent decades. The coal economy-based Appalachian region has historically been poorer than much of the U.S. For decades, it had some of the lowest per-capita income levels and highest poverty rates in the country (Lobao et al. 2016). When coal production began to shift west in the late 1960s, Appalachia's mines began to struggle. By 1998, Appalachia's share of U.S. coal production had fallen by more than half to 41 percent, and continued to decline, reaching 27 percent in 2018 (EIA 2019). Meanwhile, its national share of coal employment declined from 85 percent in 1954 to 57 percent in 2018.

The declining fortunes of the coal industry has exposed Appalachian communities to severe negative economic shocks. Despite declining share, Appalachia's coal-country remains quite vulnerable to the fortunes of coal mining. During the coal industry's rise, communities across Appalachia became dependent on the coal economy and coal employment, whether in coal mining or in associated coal supply chains. The severe and ongoing decline of the sector has resulted in widespread economic dislocation, requiring communities to adjust to new market realities. The extent and timing of the adjustment varies from one county to the next, as do the resulting economic outcomes. The Appalachian Regional Commission (ARC), which operates in 13 states and 420 counties, was established in 1965 to address these issues.

This study identifies Appalachian counties that have successfully transitioned from dependence on coal while sustaining growth, and assesses factors that facilitate more successful community transition. The key goal is to determine why some communities perform better to draw lessons for other communities facing transition challenges. The criteria we use to define "successful" transition are (a) a near total phase-out of coal jobs from a previous level of dependence, and (b) a shift to alternative economic activities sufficient to sustain a growing population with rising household incomes and thus improving economic well-being.

We identify the main variables associated with successful economic transition, based on evidence from a wide-ranging literature review. We examine the large body of literature on the impact of resource-dependence on economic development in Appalachia and elsewhere, the economics of boom and bust cycles, challenges related to the so-called "natural resource curse" and lagging regions. We reach beyond the traditional economics literature to include geography, demography, and sociology. We measure performance on key variables across the 420 ARC counties and rank the best performing counties. Four counties emerge as "successful" under our criteria: *Athens and Noble Counties in Ohio; Laurel County, Kentucky; and Sequatchie County, Tennessee.*

We check the validity of our initial results by examining the performance of these counties along other metrics of community well-being, such as population growth rate, mining and coal employment shares, median household income. We also compare their performance to average performance of three sub-groups of ARC counties: those with the top-10 fastest growing populations, the 10 counties that comprise median-growers, and the 10 counties that are the slowest growers. In a second check of robustness, we assess additional factors deemed in the literature to contribute to local economic development: agglomeration economies, human capital, economic diversification, population age

structure, proximity to metropolitan areas, natural amenities, extent of urbanization, topography, inequality, unemployment, minority population share, social capital, government capacity, and health outcomes. We assess the extent to which these factors may have contributed to successful transition for each of the four counties.

Finally, we complement our quantitative findings with case-studies on each "successful" Appalachian county (and one non-Appalachian county, for comparison). Our case study approach combines qualitative methods (key informant interviews), with secondary sources to shed light on the opportunities and resources within each community that likely contributed to relative transition success. These "deep-dive" assessments focus especially on the role of distance to larger urban centers, road infrastructure, local non-mining economic activity, local government institutional capacity, and local social capital networks.

The following conclusions emerge from our combined analysis:

- **Very few Appalachian counties have managed a positive transition from coal dependence.** Of 222 ARC counties with a high level of coal activity at some the period after 1950, only four counties managed to transition out of coal and remain economically viable communities with sustained population growth.

- **In terms of economic well-being, the level of success of the four counties is modest.** While the four counties have grown in population and diversified their production, and most have experienced significant poverty reduction, average household incomes remain low and poverty rates exceed national and ARC averages.

- **Severe economic structural impediments across Appalachia constrain growth.** Being small and remote, most ARC counties have limited access to labor markets with more and diverse job opportunities. ARC counties have low levels of physical capital, especially infrastructure, and high transportation costs. Human capital is also low, with lower educational attainment and lower quality education and health services.

- **Non-structural impediments reinforce poor economic outcomes and reduce local economic resilience.** Historically coal-dependent communities exhibit less economic diversification, modest manufacturing activity, problematic patterns of "boom and bust" cycles, and low levels of entrepreneurship.

- **Institutional capacity and social capital have helped some counties transition more successfully.** Local government institutional capacity and social capital are generally low across the ARC region compared to national averages. Our case studies highlight examples where local government capacity to design, finance, and implement economic development initiatives in collaboration with local civil society appears to have helped sustain transition impetus.

- **Transition paths in our four "successful" Appalachian counties each have their own unique features and success factors, making it difficult to generalize approaches for other counties.** ***Athens County's*** economic development has centered around its large public Ohio University which supports direct and indirect jobs and generates local social capital. ***Noble County*** was able to attract a large public investment to build a state prison, which has served as an economic driver. While infrastructure investment is a common theme in our successful counties, this is not sufficient to guarantee successful transition from coal as much of Appalachia has received significant investment, at least with respect to road infrastructure. That said, improved roads helped our four successful counties by increasing connectivity to larger metropolitan areas, manufacturing chains, and to living, tourism, and recreational opportunities. ***Laurel County*** became a regional hub following investment to construct two major highways—including Interstate-75, which linked the area to northern manufacturing centers—as well as a regional airport, a hydroelectric power dam, piped water supply, and industrial parks. ***Sequatchie County*** benefited from investments in highways to access nearby Chattanooga, a large metropolitan market offering diverse job opportunities.

Our ability to draw specific policy lessons based on the economic development patterns in Appalachia is limited. This would require assessing general and coal-specific policies at the county, regional, state, and federal levels, as well as employers' and workers' incentives in the region, and fiscal and public investment stances and capacity of particular counties or states. This is beyond the scope of our research.

Nonetheless, our analysis highlights some broad policy areas for addressing common

economic development impediments in Appalachia:

- **Enhance connectivity**: Infrastructure investments alone are not enough to ensure successful community transition from coal dependence. But remote communities need connectivity—whether in the form of roads or digital connections—to larger markets to grow, achieve scale economies, match excess labor with nearby job markets, and even to connect people to recreation and tourism opportunities.

- **Invest in human capital:** Enhancing human capital through investments in education and health will improve residents' well-being and help raise workers' productivity, allowing them to compete for better, higher-skilled jobs and generate more added value. In the absence of employer labor demand, however, human capital investments may have negligible returns and risk frustrating workers with heightened expectations for jobs that are not locally available. Successful investments in education and training align curricula to identified private sector needs and/or focus on building entrepreneurial capacity.

- **Seek economic diversification to ease "boom and bust" cycles:** Coal-dependent communities must move beyond volatile coal "boom-bust" cycles associated with long-term economic and social costs. Government and civil society must facilitate new economic activities and attract investments in new, job-creating firms that serve local or regional markets or beyond.

- **Build local institutional capacity:** Diversifying sectors of economic activity requires institutional capacity to develop a suitable business environment. This includes designing and enforcing the right mix of rules and regulations and providing public goods consistent with economic development, but also coordinating with local stakeholders and regional agencies to stimulate private sector activities, such as through investment incentives or promoting public-private partnerships (PPP) in priority sectors.

- **Coordinate economic development strategies:** Counties that are economically constrained need a coordinated set of economic development strategies and approaches to (a) foster larger economic agglomeration and/or linkages to larger regional/national/global markets, and (b) exploit natural amenities in a sustainable manner that can attract demand for local services. Not all communities are equally endowed, so policymakers will have to weigh tradeoffs between propping up very small communities and investing in areas with higher potential. This will require deep analysis of communities' long-term sustainability, and consideration of alternative approaches, such as programs to facilitate out-migration.

Introduction

Economic transition away from dependence on coal mining can be difficult and costly, but can yield significant medium-term gains. As nations move away from coal production and coal-based energy generation, the transition creates short-term economic disruption to coal communities, notably through job losses and severe economic recession. In the medium term, however, transition can generate "winners", both locally and in other regions. Displaced coal sector workers may find jobs in more sustainable and more productive industries. Environmental degradation from mining activities can give way to restoration and conversion of natural resource assets. And both coal and noncoal regions can benefit from reduced pollution and healthier people, directly improving human capital. But local economic downturns can also persist to the point that economic decline threatens a community's viability. The likelihood of this more pessimistic outcome increases in coal regions that are already lagging their non-coal counterparts in terms of economic well-being.

This paper examines the transition away from coal mining in the Appalachia region of the United States and the impact on local communities; the aim is to identify factors that helped some communities transition more successfully than others. The analysis looks beyond traditional economic factors, and takes into account broader social and institutional aspects germane to the community capitals literature. Whether driven by new market realities or the imperative to mitigate climate-change, coal communities in other countries will need to transition to alternative economic activities, and can benefit from the experiences of coal regions in Appalachia or elsewhere.

The Appalachia region has been significantly affected by coal sector decline dating back more than a half-century, but intensifying over the past several decades. It is a mostly rural region spanning the Appalachian Mountain range, nearby foothills, and contiguous areas, such as the Shenandoah Valley. The region has historically lagged in terms of socioeconomic development, and its reliance on coal likely slowed the pace of long-term growth. The Appalachian Regional Commission (ARC) was established in 1965 to address these challenges. Today, ARC covers parts of 13 states and includes 420 counties.[1]

Appalachia has some of the lowest per capita income levels and highest poverty rates of any U.S. region (Lobao, Partridge, Zhou, and Betz 2016). Appalachia historically has been the U.S.'s primary coal producing region since the early 19th century, typically accounting for four-fifths of national coal production. Appalachia's reign as the dominant coal producer in terms of its national share of production began to wane in the late 1960s as coal production began to shift west. By 1998, Appalachia's share of U.S. coal production was 41 percent and fell to 27 percent in 2018 (U.S. Energy Information Agency, EIA, 2019).[2] While total U.S. coal production fell 6 percent over this 20-year period, Appalachian coal production fell by 41 percent (EIA 2019). These changes, along with the legacy of poverty in Appalachia, make its coal-country communities particularly vulnerable.

Despite a significant body of research, certain knowledge gaps remain regarding the patterns of local economic transition in Appalachia and why some communities transition more successfully than others:

- **Most research looks at national rather than community-level data and outcomes.** While numerous studies address changes in the U.S. energy industry, national studies tell us little about how local populations adapt in affected areas.

- **Most community studies focus on mining as an aggregate sector and/or other types of resource extraction.** Studies rarely disaggregate coal mining in terms of community effects (Betz et al. 2015; Lobao et al. 2016). For example, researchers examined general boom/bust cycles in the energy industry and the "natural resources curse" under which natural resource-intensive locations have lower long-run growth rates when averaged over boom and bust cycles (Van der Ploeg 2011). Research

[1] Though we will use the terms Appalachian region and ARC interchangeably, the ARC has expanded over time and covers more territory than traditional Appalachia.

[2] EIA will refer to the U.S. Department of Energy's Energy Information Agency's Annual Energy Outlook. The annual outlook is one of the most respected sources of energy data and forecasts in the world. We cite the Annual Energy Outlook so often that we will simply refer to the associated citations as "EIA" and the year of the outlook.

on employment in the U.S. energy industry devotes relatively more attention to the oil and gas industry, which rapidly expanded after 2006.

- **Existing research tends to use a case-study approach focused on specific communities, which cannot be easily generalized.** Few systematic, quantitative studies exist in part because researchers have lacked detailed employment data that span small communities.

- **Recent quantitative research into the coal industry's effects on communities is rare.** Studies have examined the boom/bust cycles of the 1970s and 1980s (for example, Black et al. 2005) or the long-rn 20th century natural resources curse (Deaton and Niman 2012). There are some exceptions, including Lobao et al. (2016) and Betz et al. (2015), who analyzed changes in coal employment and effects on poverty rates, household incomes, and other variables from 1990 to 2010.

- **Factors that might lead to positive local outcomes in the wake of coal decline are not well-studied.** Betz et al. (2015) note that coal mining employment could influence a wide range of community attributes, including local entrepreneurship and employment in retail and accommodation (for example, tourist industries), which affect the degree to which communities could transition to other economic sectors. They find that Appalachian communities

with a larger share of coal employment had lower entrepreneurship rates. Historical studies and case studies of the region (Billings and Blee 2000, Duncan 2014, and others) also explain how coal mining affected community development, including by weakening local government and institutional capacity to address residents' needs. These studies point to the importance of considering a broad range of community factors that might influence future socioeconomic outcomes.

- **Limited temporal focus represents another gap in existing literature.** A majority of studies examining community-level impacts (positive or negative) on coal or other mining employment focused on a single or specified point(s) in time, rarely addressing the long-term consequences of transitioning from coal (with the exception of case studies). To our knowledge, no studies have determined the time period needed to make successful adjustment. For Appalachia, existing research has not established how well communities have adapted to this shift from coal since World War II.

This paper aims to address these knowledge gaps by deepening understanding of factors that contribute to communities' ability to transition successfully from reliance on coal, and offers some broad policy implications. Drawing from the wider social sciences literature on factors that contribute to community well-being and successful transition, we empirically test the relevance of these factors for Appalachia using statistical models that exploit community-level differences in socioeconomic outcomes from the 1950 post-War period to the present. This empirical approach enables us to track Appalachian communities over the long term and document the degree of recovery across 99 coal-dependent counties. We complement this quantitative approach with qualitative case studies, and draw generalizable lessons about community adjustment and policy implications.

We focus on three analytical questions critical for understanding the transition process away from dependence on a single industry and for identifying the challenges and barriers to community socioeconomic revitalization.

- **Which communities made a relatively more successful transition away from coal mining employment?**

- **What were the socioeconomic outcomes in these communities?**

- **What factors mattered for successful transition?**

This report is organized as follows. The next section reviews and synthesizes the literature on community well-being during periods of transition. The third section describes historical trends in coal industry production and employment. The fourth section presents our quantitative methodology for identifying communities that transitioned beyond coal, and identifies four counties that emerge as "successful". The fifth section documents factors explaining why some Appalachian communities have fared better than others, based on both quantitative and qualitative analyses. The sixth section more specifically describes the underlying economic development climate for each of five case-study counties, including the role of highways. The concluding seventh section synthesizes the findings to outline lessons learned and general policy implications.

Factors Related to Prosperity and Poverty Across Communities: a Synthesis of Related Research

This section synthesizes a wide range of studies to gauge factors that are important in driving community recovery in the wake of coal transition. We summarize the conclusions of this large and disparate literature by dividing it into: (a) studies on general factors that affect prosperity and poverty across U.S. communities, and (b) targeted case studies that examine communities experiencing natural resource, energy, and other industry transitions.

General Factors Determining Prosperity and Poverty Across Communities

To determine factors that matter for community recovery, it is useful to draw first from the large social science literature on why U.S. communities vary in terms of prosperity and poverty. These studies identify persistent structural conditions that either hinder or facilitate socioeconomic well-being, as measured by outcome indicators such as poverty rates, population growth, income levels, inequality, job growth, and unemployment. Numerous and wide-ranging studies from economics (Blank 2005; Partridge and Rickman 2006; Weber et al. 2005), sociology (Brown and Schaftt 2011; Lobao 2004), geography (Glasmeier 2002), and regional science (Isserman, Feser, and Warren 2009) look at determinants of U.S. communities' socioeconomic well-being. Much of this work specifically addresses structural conditions in rural America, making it more relevant for analyzing Appalachia (See Appendix A, Table 1 for a complete list of studies reviewed).

This research helps us identify potential key structural factors that enable some communities to fare better than others when experiencing similar declines in coal mining employment. Studies commonly recognize three sets of structural determinants of community well-being:

a. Geographic attributes, such as regional location, urban-rural location, distance from metropolitan areas of varying size, and degree of urbanization including population.

b. Local economic structure, or the quantity, quality, and mix of local employment sectors.

c. Sociodemographic factors, such as race/ethnicity, age, education, gender, and family structure that reflect residents' structural vulnerability.

Community socioeconomic well-being (lower poverty and higher income) historically has been greater in metropolitan counties, rural counties closer to metropolitan centers, and places outside the U.S. south (Blank 2005; Partridge and Rickman 2006). Socioeconomic well-being is also associated with better-quality employment sectors, such as higher-wage service industries (producer services) and, at least in the past, higher manufacturing employment (Cotter 2002; Lobao and Hooks 2003; Moretti 2012; Moller, Alderson, and Nielsen 2009). Communities with a smaller share of structurally vulnerable populations—such as those with higher educational attainment; a higher share of working-age population; fewer single-parent, female-headed households; and lower racial/ethnic minority population—generally have lower poverty and higher incomes (Partridge and Rickman 2006; Lichter and Cimbaluk 2012; Voss et al. 2006).

Local institutional factors, such as local governmental capacity and social capital, can also promote community prosperity (Blank 2005; Weber et al. 2005). While few generalizable studies have empirically tested these relationships, they provide some evidence that county government administrative capacity (Lobao et al. 2012) and local social capital (Isserman et al. 2009) are associated with lower poverty and greater prosperity.

The empirical analysis presented below assesses these potential correlates of successful transition. Based on the large body of work on prosperity and poverty across communities, we test the hypothesis that coal communities characterized by more favorable structural conditions—geography, economic structure, and a smaller vulnerable population—along with greater government capacity, are likely to fare better when transitioning from coal.

Communities Experiencing Natural Resource and Other Transitions: Targeted Literature Review Detailing Factors Associated with Well-Being

We draw more detailed evidence on determinants of success and revitalization from the literature on natural resource and other transitions. While this literature also covers the four broad categories mentioned above, it concludes that natural resource-based communities such as in Appalachia are even more constrained with regards to geographic location, economic structure, population vulnerability, and institutional capacity.

Overlapping social science frameworks stress that resource-dependent regions historically tend to fare poorer. Experts have often noted some key negative factors present in many extractive industries: a history of exploitative relationships, distinct phases of development, non-local market structure, and susceptibility to boom-and-bust shocks (Freudenburg and Wilson 2002).

Economists have often pointed to the "natural resource curse". Natural resource-intensive settings appear to have lower long-term growth when averaging over the boom-bust cycle, explained by lack of alternative labor market opportunities, volatility in commodity prices, and underinvestment in education (Partridge et al. 2013). In sociology, Freudenburg's (1992) classic research explains similar processes that jeopardize community well-being. He notes that communities tend to become "addicted" or over-adapted to extractive industries. Peoples' expectations and community institutions revolve around the industry, making inevitable busts particularly devastating. Extractive communities become over-specialized, and periodic shutdowns increase unemployment (Freudenberg and Wilson 2002). Finally, the literature describes the problem of "path dependence", whereby extractive industries give rise to a self-reinforcing development path in communities, which displaces other industries, fosters less diverse local economies, and leads to underinvestment in education and human capital. The remote rural location of many extractive communities exacerbates these factors.

We narrowed our focus to review literature on transitioning communities that share similar characteristics to Appalachian coal communities. Our aim was to identify factors that facilitate or hinder transition and recovery in Appalachia. This encompasses communities facing economic shocks—including those stemming from energy/natural resource transitions related to oil and gas production—and support activities for coal and oil and gas industries, including electric power generation, petroleum refining, and natural gas distribution. We also considered studies addressing changes in small, rural communities, such as military base closures. Finally, we include previous studies on changes in coal mining and its effects on communities. The studies we analyzed—which comprise academic journal articles, as well as government and non-governmental agency reports—vary by methodology, thematic areas of focus, and impact indicators (see Appendix A).[3]

We draw some generalizations based on review of 37 studies.[4]

- **Mining and coal-dominated communities fair worse on welfare outcomes.** Large-scale quantitative studies examining changes in the mining sector across the U.S. tend to find statistically significant negative impacts on community poverty, incomes, employment, population growth, and other measures of well-being (Betz et al. 2015; Black et al. 2005; Cook 1995; Douglas and Walker 2017; Freudenburg and Wilson 2002; Lobao et al. 2016). This finding might seem obvious, but these impacts do not necessarily hold for employment in other industries such as service sectors.

- **The timing of transition matters.** Mining effects on community wellbeing tend to be positive in times of price upswings and negative when prices are low (Freudenburg and Wilson 2002). This also holds for coal mining (Betz et al. 2015; Black et al. 2005; Lobao et al. 2016). The uncertainty makes it difficult for communities to adjust for the "natural resource curse." Haggerty (2014) finds that the longer counties specialized in oil/gas (over a 30-year period), the lower the education and income levels. The boom/bust cycle has implications for local support for extractive industries. As noted, communities over-adapt to extractive industries (Freudenburg 1992), with residents assuming busts are temporary and that conditions will return to "prosperity". Local receptivity to diversification or alternative industries is cyclical, and depends on commodity price movements.

- **The region where transition from mining occurs seems to matter.** For resource extraction, communities in Southern U.S. states appear to fare worse and Western states better (Freudenburg and Wilson 2002; Lobao et al. 2016; Stedman et al. 2012). This finding could be due to relatively worse initial structural conditions in Southern states, such as poorer quality jobs or lower education.[5]

- **Community structural characteristics matter for adaptation.** Three key sets of barriers across coal and mining communities exist: (a) geography and degree of remoteness from cities (Douglas and Walkers 2017; Haggerty 2019; Haggerty et al. 2018; Snyder 2018); (b) availability of alternative economic opportunities (Carley 2018; Deaton and Niman 2012; Haggerty 2014; Haggerty et al. 2018); and (c) population vulnerability, reflected by low educational attainment (Douglas and Walker 2017; Haggerty et al. 2018) or by an aging workforce (Haggerty 2019). These structural barriers limit workforce upgrading through various channels; for example, low digital literacy limits job search and occupational mobility; and transportation is important for accessing college and training centers, as well as employment elsewhere (Jolley et al. 2019). Training, community college programs, and new professional opportunities, including those in alternative energy industries, can improve residents' ability to adapt to change (Carley et al. 2018).

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[3] Note that we limit our geographic coverage to the United States.

[4] Note that although the selected literature represents substantive research on the topic, it is not exhaustive of all past work.

[5] It could also be due to regional variations in employment quality and other regional features of the extractive sector, but the studies reviewed do not provide systematic comparisons within that sector.

- **The quality of the local environment and presence of natural amenities matter.** Local environmental degradation hampers future development and the ability to attract tourism and other non-extractive industries (Appalachian Law Center 2019; Haggerty et al. 2018; Kelsey et al. 2016). Places with higher quality of life—including natural amenities as reflected in climate, topography, and water area—are more likely to attract migrants, especially retirees (Isserman et al. 2009; Partridge and Olfert 2011).

- **The transitioning populations are aware of the challenges their communities face.** The barriers acknowledged by locals are similar to those indicators cited in quantitative studies. Research based on opinion surveys (Besser et al. 2008; Graffe 2019) and focus groups (Carley et al. 2018) point to barriers such as lack of alternative employment, low education, and boom/bust economic cycles. In Appalachia, residents' concerns about their community shifting to non-coal employment include fear of potential job loss and business closures, detrimental effects on schools and retail as families leave, lack of affordable housing elsewhere and high attachment to the community (mobility barriers) (Carley et al. 2018).

- **The prevalence of a "coal culture" can impede transition in Appalachia.** Carley et al. (2018) note that coal mining generational employment has fostered a community bond and identity with the industry. Haggerty et al. (2018) point out that residents' resistance to change can arise when populations blame restrictive environmental regulations, while they ignore the larger role of markets and price competition from, for example, natural gas. Carley et al. (2018) note that promising return of coal jobs discourages community and individual efforts to adapt to change. Long-term dependence on coal delays acceptance of transition, but in any case, populations find it difficult to move elsewhere (Haggerty 2019).

- **Rural communities are not homogeneous, and the benefits/costs of transition vary by social group.** For example, Appalachian communities with a greater share of coal employment tend to have a lower share of sole proprietors, higher disability rates, and a higher share of poor people (Betz et al. 2015). Much has been written about the uneven impacts of natural gas expansion, with communities divided among those who benefit and those who do not. Extractive industries employ a higher proportion of men, and women tend to have fewer local employment opportunities. Declines in extractive employment affect family structure, and may increase the share of female-headed households (Cook 1995).

- **Local "social capital" is an important factor for transition.** Communities with higher levels of social capital—strong inter-group relationships within the community—tend to be more resilient. In the case of plant closures, Besser et al. (2008) find that residents report less negative overall quality of life where social capital is higher.

- **Low capacity of local governments represents an institutional barrier to transition.** Lack of local government capacity in rural and small U.S. communities has long been noted (Johnson et al. 1995; Lobao and Kelly 2020).[6] The overriding problem is replacing and stabilizing income streams (Haggerty et al. 2018). Haggerty

[6] This has been documented in studies of transition planning, but there are few empirical analyses of actual transitions.

(2019) summarizes the barriers small or rural governments face when coal plants close, including limited administrative leadership capacity (for example, little or no planning staff); limited staff and ties to state or regional actors, which limits ability to apply for federal and state assistance; and low fiscal autonomy, which limits local budgeting authority. Haggerty et al. (2018) and Haggerty (2019) stress that small communities often lack access to a dedicated transition fund, requiring them to substitute other funds or secure external funding. They lack adequate information to assess fiscal risks and state and federal fiscal policies (Haggerty 2019). In analyzing the impacts of coal-power plant closures in an Appalachian county, Jolley et al. (2019) draw similar conclusions, noting that local governments have limited fiscal resilience to recover from lost tax revenue.

- **Conventional economic development policies to attract business investment, retain local businesses, and develop the workforce have variable effects.** Benefits from economic development policies typically appear to be modest (Daniels et al. 2000), and strategies tend to be overly focused on retaining or attracting a single large employer (Haggerty et al. 2018). No policies/programs work everywhere, and successful models appear difficult to replicate. Outcomes have been difficult to evaluate and there are ambiguous results across studies.

- **Military base closures, while similarly affecting small communities, differ from transitions from extractive industries.** Military base closures follow the Federal Base Closure Act-mandated rigorous planning protocol for engaging local communities. The Department of Defense provides economic development grants and technical support to assist communities in redevelopment. Cowan (2012) notes that while rural communities typically find it harder to recover from a base closure than urban ones, the differences are not very large.

- **Federal policy addressing the needs of rural communities has been limited.** The U.S. has proxied agricultural-policy for rural development, focusing on the needs of the farm population as opposed to the broad rural nonfarm population. In place of general rural economic development, including infrastructure and facilities, rural areas rely more on social protection transfers targeted to individuals, such as disability assistance (Bishop 2017). Haggerty et al. (2019) note that in the case of coal plant closure federal assistance is over-prescribed, poorly targeted, and ultimately limits local flexibility to use funds to meet local needs. Various programs have offered financial resources to transition areas. For example, the Appalachian Regional Commission (ARC) has long provided grants and other programmatic assistance. The federal Partnerships for Opportunity and Workforce and Economic Revitalization (POWER) initiative, established in 2015, offers a tool-kit of community development strategies to provide workforce training and economic development assistance in Appalachian coal communities. POWER aims to increase regional economic diversification, job creation, capital investment, and re-employment for displaced workers. As of fall 2019, it had provided $190 million in grants spanning 239 projects in 326 ARC counties. However, Morris et al. (2019) note that the wider goal of investing $9 billion in total federal aid has not been realized.

SECTION 3

U.S. Coal Mining: Past Trends, Future Prospects

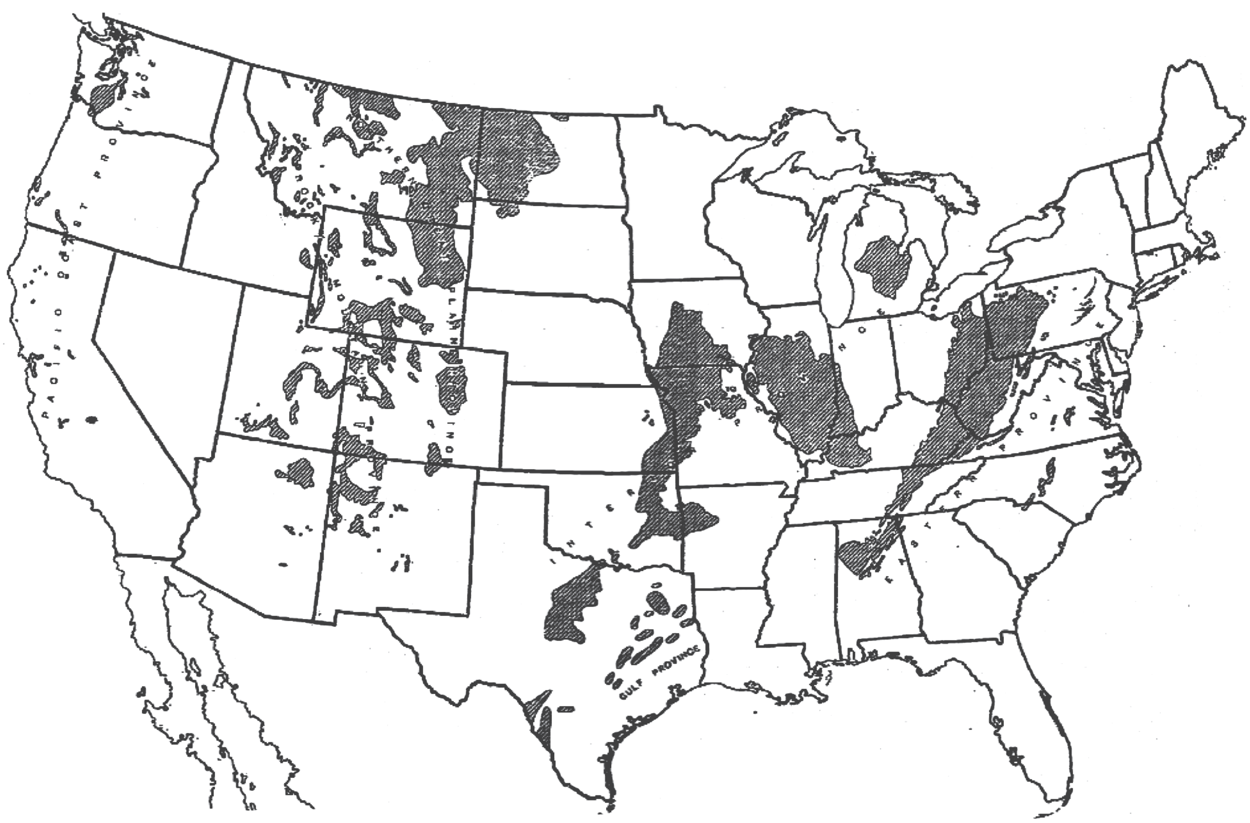
Overview of Coal Mining in the U.S.

The 1919 map of coal fields (Figure 3.1)[7] identifies significant coal deposits in several continental U.S. regions. The large swath of Appalachian coal fields runs from northern Pennsylvania through central Appalachia, to its southern boundary around Birmingham, Alabama. The key competing regions to Appalachian coal are the western Kentucky/ southern Illinois coal fields and, beginning in the 1970s, the Powder River Basin (PBR) centered in northeastern Wyoming.

Appalachia has long been the center of America's coal industry. Appalachian coal mining began in Pennsylvania in the early 19th century. By 1954, coal employment was heavily concentrated in the region where Ohio, Pennsylvania, and West Virginia meet, an area of rich bituminous coal fields (Figure 3.2). Other dominant regions for coal production and coal employment were northeastern Pennsylvania (characterized by high-quality anthracite coal fields used in ferrous metallurgy), and southeastern Kentucky/ southwestern West Virginia. Note the small

Figure 3.1

Coal Mining Fields in the Continental United States, 1919

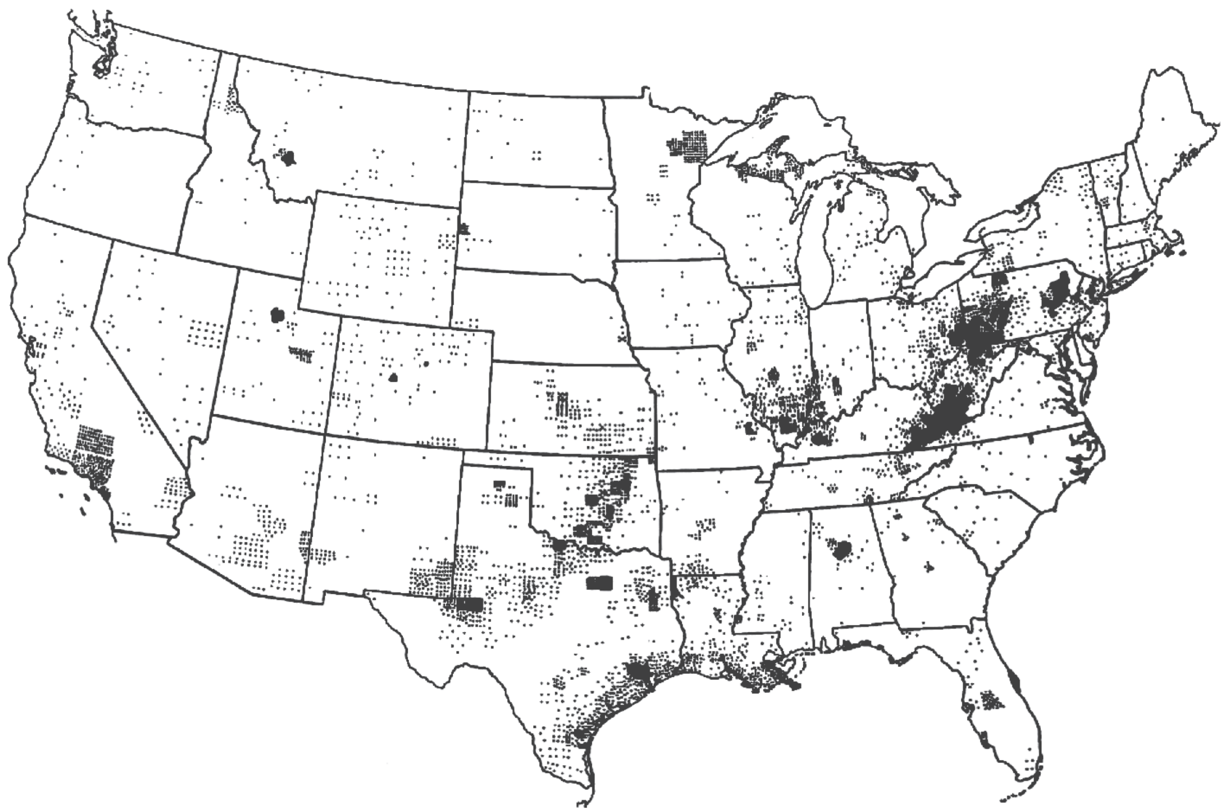


Source: 1919 Census of Mineral Industries, p. 254

[7] Appendix B Figure 1 depicts a contemporary perspective of coal fields. A careful look shows that the maps do not tangibly vary in terms of the location of reserves, although contemporary analysis provides a more accurate view of remaining coal reserves and its quality in each region.

Figure 3.2

1954 Mining Employment Intensity (each dot = 100 mine workers)



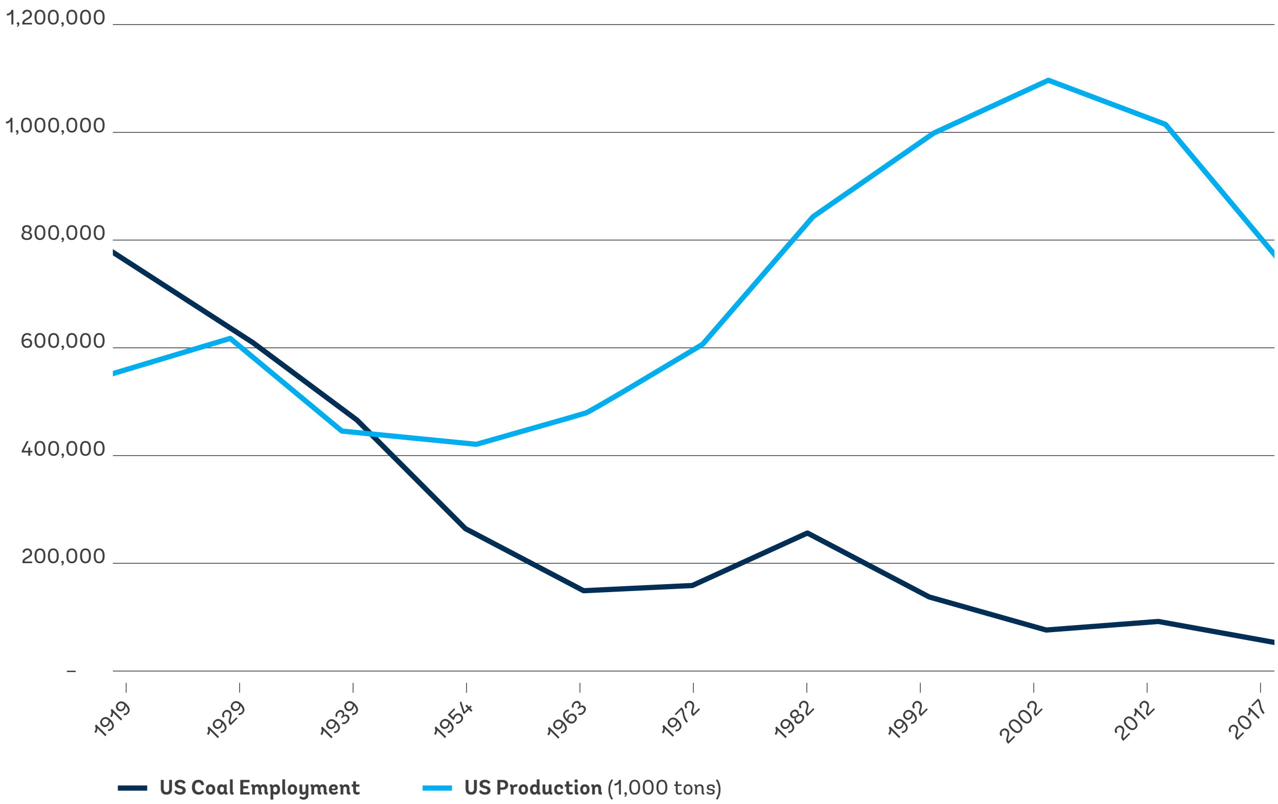
Source: 1954 Census of Mineral Industries, Vol 2. Pg. VI.

cluster around Birmingham, AL, an area endowed with both iron ore and the necessary coal for smelting the ore, allowing the region to become both a coal producer and the south's only primary iron/steel producer.

In 1919, the Appalachian coal sector accounted for two-thirds of total U.S. mining employment, but is down to just over half today. As transportation costs fell, Appalachia's productivity advantages over other U.S. coal mining regions rose, leading its employment share to rise to 85 percent by 1954. Appalachia's dominance began to wane after the mid-1960s as western coal began its initial ascent. By 1972, Appalachia's share of coal mining employment fell to about 80 percent, and continued a steady downward trend to reach 67 percent by 2002. Although it maintained employment share in the 2000-2012 period, the downward trend resumed thereafter, reaching 57 percent in 2018 (Census of Mineral Industries, various years; EIA, various years).

Figure 3.3

U.S. Coal Employment and Production



Source: U.S. Census Bureau, Census of Mineral Industries. Various Years.

Expanding coal production accompanied the national decline in coal employment. Coal production increased modestly in the post-World War I era until 1929, before declining by almost one-third by 1954 (Figure 3.3), initially due to the Great Depression and then from substitution by less expensive fuel sources, such as oil and gas. This decline was also spurred by technological changes, such as the switch to diesel locomotives. Strong economic growth after 1954, combined with rapid coal-mining productivity growth, reversed the downward trend as coal production expanded by over 250 percent by 2002. Production plateaued until about 2012 before declining by about 30 percent by 2017. A number of factors explains this most recent decline, including rising competition in coal export markets, price competition from cheaper natural gas, and increasing competitiveness from renewable energy sources.

Shifting Geography of U.S. Coal Production

The Appalachian region has lost its position as the locus of national coal production (Betz et al. 2105; EIA 1999, 2005, 2013). The 1970s saw a massive increase in western coal production, especially from the Powder River Basin (PRB) of Wyoming and southeastern Montana. Environmental regulations associated with the Clean Water Act of 1972, Clean Air Act of 1970, and Clean Air Act of 1990 increased demand for low-sulfur, less polluting western coal.[8] In addition to being low in sulfur, PRB coal is also relatively low in mercury and arsenic, giving it additional competitive advantages over bituminous coal, in light of tightened environmental regulations (EIA 1979, 2001).[9] PRB coal is also relatively inexpensive to strip mine with little surface overhang, very thick coal seams, and high-quality coal (EIA 2001).[10] By the 1970s, these lower production costs became a compelling reason to mine western coal rather than developing other energy sources (EIA 1979). Coal is bulky and expensive to transport, which historically gave Appalachian coal mines an advantage due to proximity to major eastern cities and manufacturers. But improved rail transportation from PRB mines beginning in the 1970s gave further impetus to the region's cost advantages (EIA 2001). Today, 50 to 70 coal trains leave Wyoming every day, destined to 29 states, the largest consumers being Texas, Missouri, and Illinois.[11]

The shift in coal production away from eastern regions was relatively swift. Eastern coal, mostly Appalachian, accounted for 93 percent of total U.S. coal production in 1965, but fell to 74 percent by 1978, while the respective shares for western coal were 4 percent in 1965 and 25 percent in 1978 (EIA 1979). In 1990, coal production east of the Mississippi River accounted for 61 percent of the total (47 percent from Appalachia), compared to 39 percent produced west of the Mississippi River (EIA, 1993). In addition to falling transport costs, increasingly stringent environmental regulations accelerated the shift westward. By 2000, western coal share reached 52 percent of national production while Appalachia's fell to 38 percent.

Innovations in unconventional shale oil and natural gas drilling ("fracking") led to explosive growth in oil and gas production after 2005. The low price of natural gas motivated rapid and widespread substitution for coal. During the 1990–2008 period, coal consistently accounted for 48 to 53 percent of U.S. electricity generation, but fell to 37 percent in 2012 and 24 percent in 2019. By contrast,

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[8] Although Appalachian coal has a higher heating value than PBR coal due to its lower moisture content of only about 7%, it also has about one-and-a-half-times more ash (the toxic residue that remains after burning coal), about two- to five-times more sulphur, which causes acid rain and other air pollutants, and about ten-times more chlorine, which is associated with corroding power plant boilers (Hatt and Mann, 2015; National Academies of Sciences, Engineering, and Medicine, 2007).

[9] Source: Carrol, Chris, Wyoming's Coal Resources Summary Report, 2015. Available at: http://sales.wsgs.wyo.gov/wyomings-coal-resources-summary-report-2015/ (downloaded April 28, 2020).

[10] The Wyoming State Geological Survey describes the production-cost advantages of the PRB coal as follows: "In the Powder River Basin coal field—the most prolific in the world—coal is mined from two major coal seams, the Anderson and Canyon coals. This coal occurs in the Paleocene-age (65 to 55 million years ago) Tongue River Member of the Fort Union Formation. The mineable subbituminous coal seams in the Fort Union Formation are 60 to 80 feet thick, with a moisture content between 20 and 30 percent, and contain less than 6 percent ash and 0.5 percent sulfur. Powder River Basin (PRB) coal also includes beds in the Eocene-age Wasatch Formation, where exploration drilling has encountered coal seams greater than 200 feet thick." (Source: Wyoming State Geological Survey. https://www.wsgs.wyo.gov/energy/coal-production-mining (downloaded April 30, 2020).

[11] Wyoming State Geological Survey. https://www.wsgs.wyo.gov/energy/coal-production-mining. (downloaded April 30, 2020).

natural gas's share of electricity production rose from 12 percent in 1990 to 30 percent in 2012, and 37 percent in 2019 (EIA 2013, 2020). Appalachia itself has become a major natural gas supplier as northern Appalachian Marcellus Shale has become a key source of supply. Expected climate-change regulations also have increased demand for gas (and renewables) relative to coal, as CO2 emissions from coal are about double those of natural gas. By 2019, Appalachia's share of U.S. coal production declined to about 26 percent (EIA 2020).

Finally, large numbers of older 1950 to 1980-era coal power plants have been retired since the late 2000s recession. Between 2011 and 2017, the capacity of U.S. coal-fired power plants fell nearly 20 percent, and more closures are expected.[12] Renewable energy is also forecast to surpass coal as a source of U.S. electric generation in 2021.[13]

These combined effects—falling consumer demand in the last decade and the 50-year redistribution of U.S. coal production west—have had devastating impacts on Appalachian coal country, leading to mine closures and layoffs. Scores of U.S. coal companies have filed for bankruptcy in recent years, including giants Peabody Energy, Cloud Peak Energy, Arch Coal, Murray Energy, and Alpha Natural Resources.[14]

[12] See EIA (2019) Today in Energy. "U.S. coal plant retirements linked to plants with higher operating costs." December 3, 2019 (downloaded from https://www.eia.gov/todayinenergy/detail.php?id=42155#. on May 3, 2020).

[13] See EIA (2020) Today in Energy "EIA expects U.S. electricity generation from renewables to soon surpass nuclear and coal." (downloaded from https://www.eia.gov/todayinenergy/detail.php?id=42655#. on May 3, 2020).

[14] See https://en.wikipedia.org/wiki/Coal_mining_in_the_United_States (downloaded April 30, 2020).

There is no relief in sight for coal's near and long-term outlook. During the COVID-19 pandemic-induced recession, electricity demand has fallen, with coal bearing most of the burden (Wade et al. 2020). Coal's share of U.S. electricity generation declined by over 5 percentage points between February and April, 2020 (Wade et al. 2020). Natural gas and some renewables represent less expensive sources of electricity generation than coal. The EIA forecasts a post-COVID decline in U.S. coal production of 22 percent for 2020. There was a remarkable 41 percent annual drop in U.S. production in the week ending May 9, 2020, with Appalachia taking a disproportionate hit.[15] According to the EIA's pre-COVID medium to long-term forecasts, coal's share of electricity generation was already expected to decline to 17 percent by 2025 and 13 percent by 2050, with renewables becoming increasingly competitive (EIA 2020).

Long-term U.S. Coal-Mining Employment Trends and Productivity Growth

U.S coal mining employment in the last century reflects rising concentration in Appalachia until the mid-20th century, with dissipation thereafter as coal production migrated west. Within Appalachia, the last century saw spatial redistribution of coal activity from Pennsylvania and northern Appalachia toward central Appalachia centered on the region where Kentucky, Virginia, and West Virginia meet. As coal mining moved, coal employment rapidly declined, mainly driven by labor-saving productivity growth (Appendix B Figure 2 presents annual coal employment for 1929 to 2019).[16]

Measured as tons of mined coal per miner, coal sector productivity rose drastically over time (Figure 3.4). Beginning in the late 1960s, steady economic growth and rising energy prices, due to supply constraints for oil and natural gas, led to resurging coal demand. The ensuing search for new coal led to falling productivity. The result was an 83 percent increase in mining employment between 1968 and 1982. The 1970s coal boom was the only sustained one since World War I. The 1970s-to-early 1980s energy boom temporarily interrupted rising mining productivity and declining coal employment. Environmental regulations provided additional headwinds after the passage of the Clean Air Act of 1990. U.S. coal employment declined 68 percent between 1982 and 2000, while productivity increased 440 percent over the 1982-2020 period, reflecting 8.6 percent annual growth.

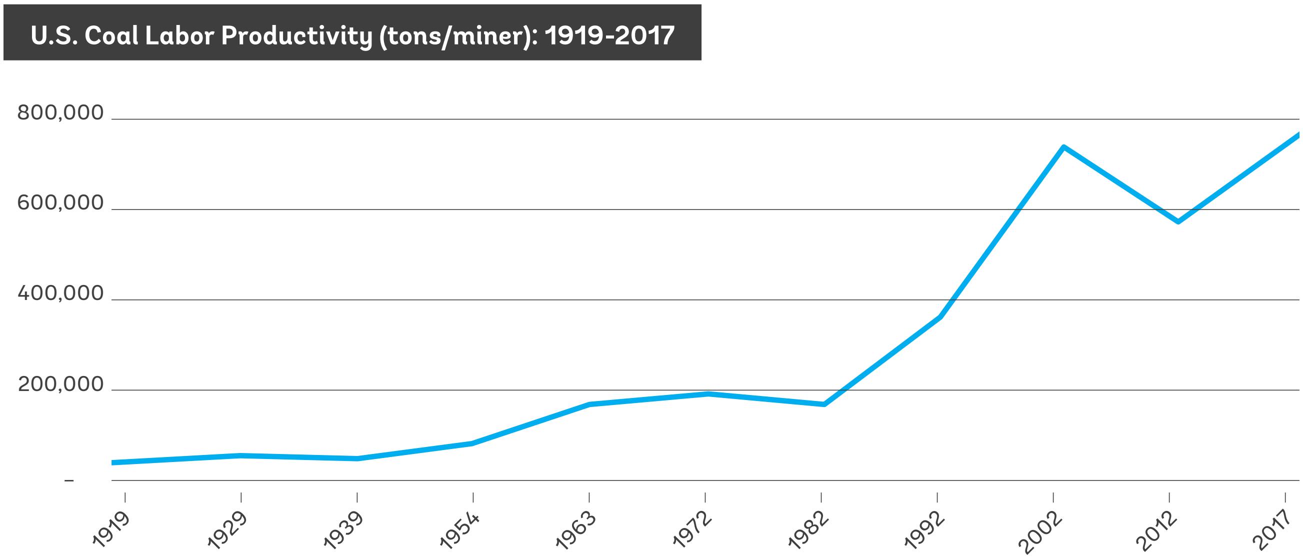
Labor productivity in Wyoming coal mines is 8.4 times greater than in Appalachia. Wyoming's largest coal mine, the Peabody Energy North Antelope Rochelle Complex, illustrates the higher productivity of western strip mines. The enterprise produced more than 98 million tons in 2018, three million tons more than produced in all of West Virginia.[17] Remarkably, only 5,558 workers, barely one-tenth of total U.S. coal

[15] Sources: https://www.eia.gov/outlooks/steo/. (Downloaded May 1, 2020) and EIA, Weekly Coal Production (downloaded from: https://www.eia.gov/coal/production/weekly/. on May 19, 2020).

[16] Constructed using an updated version of Betz et al.'s (2015) data.

[17] Ibid. and EIA 2019 Annual Coal Report, Available at: https://www.eia.gov/coal/annual/ (downloaded April 30, 2020).

Figure 3.4



Source: U.S. Census Bureau, Census of Mineral Industries. Various Years.

employment,[18] mined Wyoming's 304.2 million tons of 2018 coal production. By contrast, Appalachia coal mining employed 30,620 in 2018.

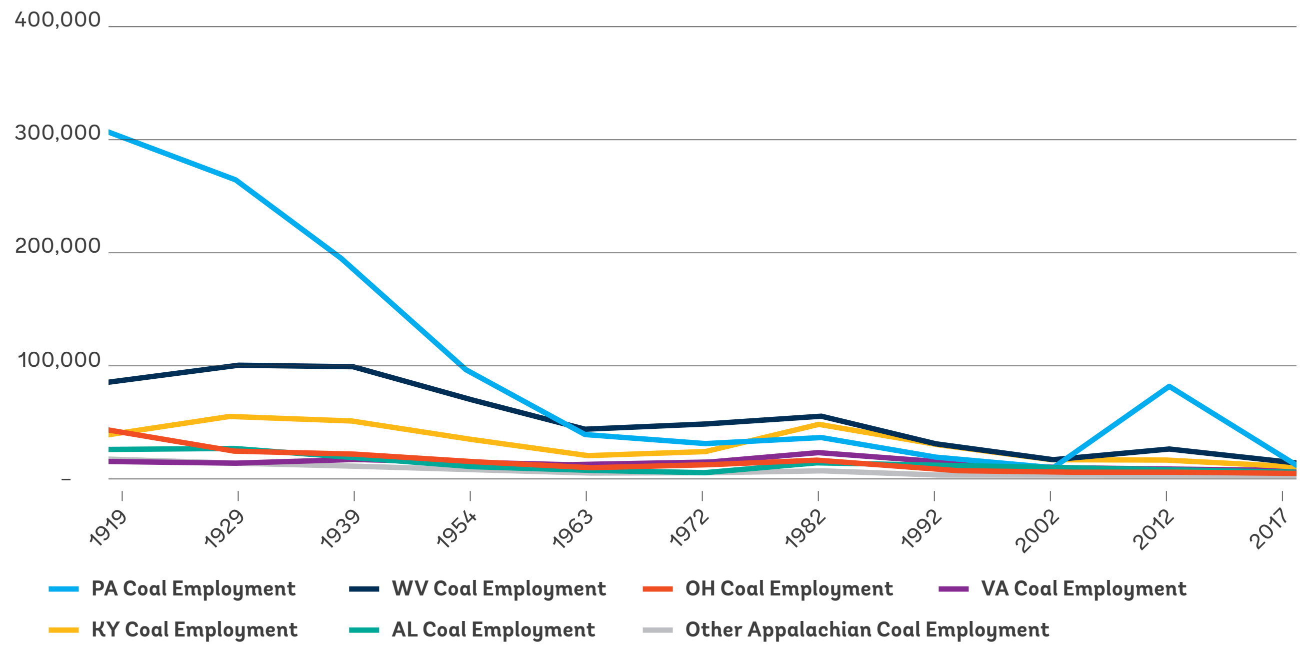
Coal experienced a mini-resurgence between 2001 and 2012, but the trend reversed around 2012. The temporary resurgence was due to a shift in electricity generation and expanding global demand. During this period, coal mining and coal mining support jobs increased by nearly one-fourth, although coal's diminished importance in the labor market meant that these gains translated into about 18,000 new coal mining jobs, far below employment levels seen in 1982. But by 2012, the increasing shift from coal-powered electric generation to natural gas had begun. Coal production fell from just over one billion tons in 2012 to about 681 million tons in 2019 (Census of Mineral Industries 2017; EIA 2020), while U.S. coal employment and coal-mining support industry employment fell 41 percent to about 56,000 workers (equivalent to a mere 0.0037% of total nonfarm U.S. employment in 2019). This compares to 777,000 coal-mining jobs in 1919 (2 percent of total U.S. employment or 2.8 percent of U.S. nonfarm employment; U.S. Census Bureau 1975 and 1999, U.S. Census Bureau Statistical Abstract, Table 1432).[19] From a peak of 863,000 coal mining jobs in 1923 (U.S. Census Bureau 1975), coal employment contracted by 94 percent over the subsequent century.

[18] These Wyoming/Appalachian productivity calculations use data from EIA 2019 Annual Coal Report, Available at: https://www.eia.gov/coal/annual/ (downloaded April 30, 2020).

[19] The source of 1919 U.S. nonfarm employment is Ghanbari, L. and M. McCaul. 2016. "Current Employment Statistics survey: 100 years of employment, hours, and earnings." Monthly Labor Review. August 2016, https://www.bls.gov/opub/mlr/2016/article/current-employment-statistics-survey-100-years-of-employment-hours-and-earnings.htm. (downloaded May 2, 2020).

Figure 3.5

Coal Employment by State (selected states)



Note 1. Data sources: U.S. Census of Mineral Industries and U.S. Economic Census, various years. For 2017, U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages. *(https://www.bls.gov/cew/).*

Note 2. 2002 MD employment and 1992, 2002 2002 TN employment are disclosed only for a discrete range and are imputed. 2017 OH employment is not disclosed and 2018 data is used. 2017 TN employment is not disclosed, so 2014 data is used. Source: 1) U.S. Census Bureau, Census of Mineral Industries. *Various Years.*

Note 3. Kentucky Appalachian coal would be overstated due to the inclusion of western Kentucky coal fields. In 1919, for example, western coal fields account for 27.6% of wage earners and 37.7% of total Kentucky coal employment in 2017 (1919 Census of Mineral Industries *and EIA, 2020, Table 18).*

Coal within Appalachia: Time and Spatial Trends

The Appalachia coal story reflects general aggressive decline, along with spatial realignment from north to central Appalachia. Pennsylvania's 300,000 coal miners in 1919 was nearly 3.5 times the number of coal miners in West Virginia. The decline in north Appalachia began immediately after World War I, while the central Appalachian coal industry experienced more volatile ebbs and flows. The northern Appalachian states of Pennsylvania and Ohio had no periods of sustained coal employment increase from 1919 to 2017 (1963-1982 was one of stagnation), whereas the coal sector in central Appalachian states experienced mini-booms with employment increasing during 1963-1982 and 2000-2010. Yet, the alternating bust-periods vastly overwhelmed any positive employment effects. The central Appalachia coal industry ultimately followed northern Appalachia, but with a lag of 20-30 years. By the 2012-2017 period, central and northern Appalachian coal employment each tracked downward. All five Appalachian states experienced a long-term collapse of coal employment: over the last century, West Virginia lost 85 percent of coal jobs, compared to 78 percent for Virginia, 85 percent for Kentucky, and 98 percent in both Ohio and Pennsylvania (Figure 3.5).[20]

For the three central Appalachian states, and especially West Virginia, coal mining played critical roles in their respective state economies through much of the 20th century. State-level employment data was not available until the Census Bureau's *1930 Census of Unemployment*. Prior to that, the federal government only collected employment data in selected industries. In 1930, PA, WV, and KY coal mining respectively represented 7.3, 22.7, and 9.7 percent of their state's nonfarm employment.[21] By 2017, coal job shares had fallen markedly to 1.9 percent in WV, 0.3 percent in KY, and 0.1 percent in VA (EIA 2019 *Annual Coal Report*; Bureau of Labor Statistics state employment data). By 2017, coal employment in the three most coal-intensive ARC states was only 14,000 in WV, 6,500 in KY, and 5,400 in PA. And between January 2017 and April 2020, total U.S. direct coal employment declined further, from 51,000 to 43,800 (BLS, CES). The shrinking footprint of once-dominant coal is striking, especially when viewed against service sector jobs. For comparison, Walmart employs 1.5 million U.S. workers, and retailer Bed Bath & Beyond employs about 65,000.[22]

At the county level, both the degree of local economic dependence on coal and the spatial distribution of coal jobs have changed substantially since 1950, illustrated by comparing Figures 3.6 and 3.7.[23] Figure 3.6[24] shows that the top one-sixth of ARC counties had mining employment shares over 40 percent in 1950, and the top one-third had mining[25] shares greater than 22 percent. Counties with the highest shares were generally located along the spine of the Appalachian Mountains from Pennsylvania to Birmingham, AL, with higher densities running from Pennsylvania through West Virginia and Kentucky. In the buffer counties outside the ARC boundary, mining shares of the labor force are very low, with the exception of the coal region near where Kentucky, Illinois, and Indiana meet to form a key "interior" coal region (Appendix B Figures 3 to 9 reproduce state maps from the 1954 Census of Mineral Industries showing the high-coal intensity local economies in Alabama, Kentucky, Ohio, Pennsylvania, Virginia, and

[20] Beginning in the 1920s through the early 1960s, key reasons for declining coal demand were the growing use of electricity, oil, natural gas and other fuels; substitution of diesel locomotives for steam locomotives; and the general rise of trucking over rail. See http://explorepahistory.com/story.php?storyId=1-9-B&chapter=0 and http://explorepahistory.com/story.php?storyId=1-9-18&chapter=0. (downloaded May 1, 2020).

[21] The 1930 employment-share data was collected from Volume of 1 of the 1930 Census of Unemployment that was collected in conjunction with the 1930 Census of Population. Using Tables 6 and 7 for each state, coal mining employment and total nonfarm employment were calculated by taking gainfully employed (approximately the labor force) minus "Class A" and "Class B" unemployed.

[22] Sources: https://www.cnbc.com/2019/03/28/bed-bath-beyond-lays-off-nearly-150-of-its-65000-employees.html (accessed April 30, 2020) and https://corporate.walmart.com/newsroom/company-facts (accessed on April 30, 2020).

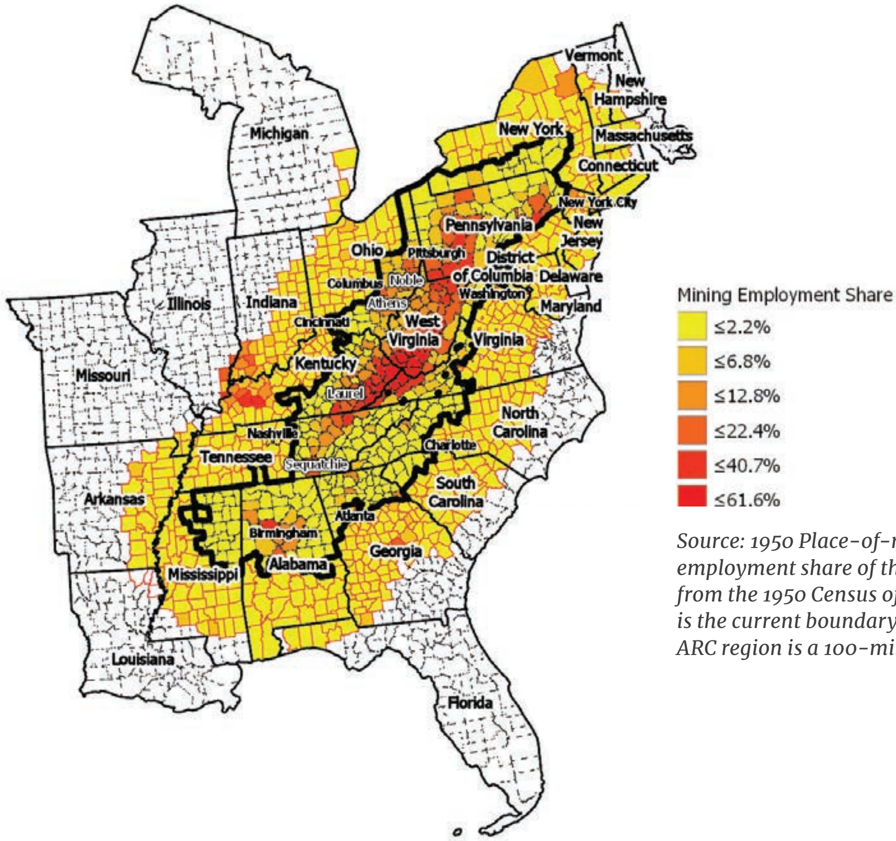
[23] Note that both Figures 3.6 and 3.7 include an additional 100-mile buffer of counties outside of Appalachia to show the contrast between the ARC region with nearby counties. Both figures are also divided into six equal-sized mining/coal employment share categories for ease of comparison, in which each category has an equal number of counties.

[24] Figure 3.6 shows the 1950 residential share of the civilian labor-force working in mining (both coal and non-coal), which for most of Appalachia is almost exclusively coal mining (especially in 1950).

[25] Combined coal and non-coal mining.

Figure 3.6

1950 County Mining Employment Shares for ARC and Buffer Counties (% of labor force)



Source: 1950 Place-of-residence mining employment share of the labor force is derived from the 1950 Census of Population. The black line is the current boundary of the ARC. Outside the ARC region is a 100-mile buffer of counties.

West Virginia).[26] The combined mapping of these states (Appendix B, Figure 10) illustrates the sheer number and spread of counties with at least 1,097 coal employees in 1950.

By 2016, 110 counties in Appalachia out of a total 420 ARC counties still had measurable coal employment, but at very low levels, averaging 3.7 percent of nonfarm employment, compared to 0.98 percent across 420 counties (2014 data), and 0.23 percent nationwide (authors' estimates). Figure 3.7[27] shows a significantly truncated concentration of coal counties in 2016; only five counties in the ARC region had a coal employment share above 20 percent. Coal mining jobs account for at least 17.4 percent of total employment in the top one-sixth mining-dependent counties,[28] and in the top one-third counties, mining accounts for between 11 and 17 percent of nonfarm employment. For the 15 most coal-intensive county economies,[29] the coal-

[26] For example, in 1954, the share of mining employment accounted for by coal in Kentucky, Pennsylvania, and West Virginia were respectively: 81%, 82%, and 88%.

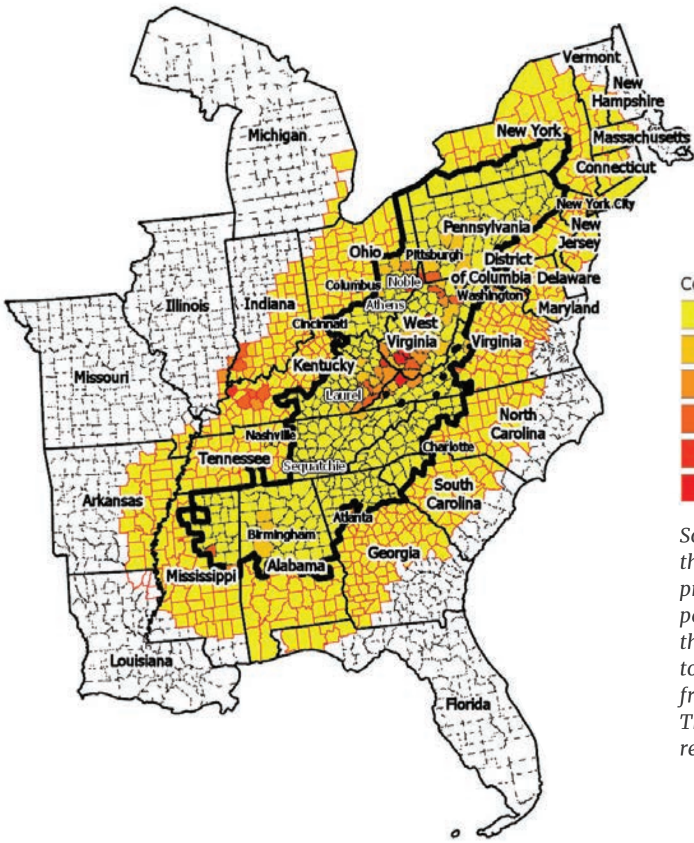
[27] Figure 3.7 shows the (place-of-work) 2016 employed coal mining share of the civilian labor force.

[28] Most mining in these states is coal mining.

[29] Nine of the top-fifteen most coal-intensive counties are in WV, one is in PA, one is in OH, one is in KY, one is in VA, and one is in MS. Nine more counties had coal-mining nonfarm employment shares above 5 percent (4 in WV, 2 in OH, and one each in KY, MS, and VA).

Figure 3.7

2016 County Coal Employment Shares for ARC and Buffer Counties (% of labor force)



Source: 2016 Place-of-work mining employment data is from the U.S. Bureau of the Census 2016 County Business Patterns as provided Upjohn Institute of Employment Research, who use a peer-reviewed linear programming model to estimate values for the cases when the federal government suppressed the information to maintain confidentiality. The county's civilian labor force is from the 2016 American Community Survey five-year averages. The black line is the current boundary of the ARC. Outside the ARC region is the 100-mile buffer of counties.

mining share of nonfarm employment ranges from 8.2 percent in Fayette County in southern WV to 33.7 percent in nearby Boone County, WV. The second highest coal mining employment share is 24 percent in Buchanan County in far southwest Virginia, the only Virginia county directly bordering both Kentucky and West Virginia. Overall, 55 of the 420 ARC counties have coal mining employment shares over 5 percent.

Today, West Virginia has the largest concentration of counties in which coal mining remains an economic driver. Thirteen WV counties have a coal mining share above 5 percent. There are a few other cases where coal mining remains important even though the share is below 5 percent.

For example, Raleigh County, WV had over 1,200 miners in 2016, but its relatively large population means that its coal employment share is below 5 percent. Kanawa County, WV (home of WV's capital Charleston) and Jefferson County, AL (home to Birmingham) also have over 1,000 coal miners but very low coal employment shares.

SECTION 4

Identifying Successful Post-transition Counties

Selection Criteria and Methodology

We use the county level as our unit of analysis to examine the community impact of transition away from coal mining, for the following reasons:

a. This is the unit ARC uses to classify the region's communities.

b. The most complete local-level secondary data are county level.

c. Counties are best suited to analyze changes over time because their boundaries are much less likely to shift than boundaries of municipalities or other places.

d. Counties are the unit of analysis most often used in rural U.S. research (Isserman 2007; Partridge and Rickman 2006).

We first define the criteria by which we measure transition, and then the criteria that define "success". A county that has transitioned must meet the following two conditions:

a. The county was dependent on coal mining sometime in the past.

b. It is no longer dependent on coal mining today (either ceased or became a "trivial" part of the local economy).

Our sample includes the 420 ARC counties plus counties located within 100 miles of the ARC region, yielding a total sample of 1,070 counties.[30] Including buffer counties provides more variation in outcomes and explanatory variables, and helps ensure we are not only considering a selected group of counties that are lagging by definition (ARC was formed to address lagging development).

We define a county as coal-dependent if its mining employment share of the labor force[31] exceeded a certain threshold in 1950 or in a subsequent period. To determine the threshold for coal-dependence in 1950, we consider the distribution of mining-intensity across the 1,070 sample of ARC and buffer counties and find that 99 ARC counties had at least an eight percent mining-share, with an average mining share of 23.7 percent. The ARC average 1950 mining share of the labor force was 6.75 percent, and the average for counties within 100 miles of the ARC was 0.8 percent. Given the decline in coal mining's importance over time, we lower the coal-dependent threshold to four percent for 1980 and thereafter.[32] An additional 123 candidate counties met the 4 percent mining share threshold in 1980, bringing the total number of "successful transition" candidate counties to 222 (original 99 plus 123).

***Population growth* is our main metric for success.** There are many aspects to economic development that might reflect successful post-shock recovery and transition,

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[30] We do not extend the buffer farther, say to include the whole country, because that would introduce significant heterogeneity into the model.

[31] For data reasons, we use mining share of the labor force rather than coal mining share. We address any potential bias at the county level below. Moreover, because coal was and still remains the dominant ARC mining industry, "mining-intensive" typically means "coal-intensive".

[32] This threshold may seem low but recall that we use the mining employment as a share of the civilian labor force (which includes agriculture, proprietors, unemployed), not nonfarm employment, and this yields smaller share values. Between 1950 to 1980, U.S. coal mining employment fell 46 percent and the civilian labor force rose 72 percent.

Box 4.1

The case for using population growth to measure "success"

Population growth is the most common metric for assessing regional success in U.S. studies. Betz et al. (2015) found that population growth highly negatively correlates with intensity of local coal mining employment, and they found a statistically significant causal link between coal mining employment and population decline. Other variables associated with economic prosperity —per-capita income, poverty rates, and growth in median household income—positively correlate with population growth. Moreover, population growth directly captures the movement of people in and out of these regions based on economic as well as socioeconomic factors. Population data is also readily available at the necessary disaggregated levels.

The standard model of American urban and regional economics is the Spatial Equilibrium Model (SEM), which posits that people weigh the trade-off between income and quality-of-life, and locate in a place that gives the most satisfaction (Faggian et al. 2012; Partridge 2010). Given this trade-off, low median household income is not necessarily a sign of failure in settings where quality of life is high. The SEM assumes that households are freely mobile in the medium term; our chosen period of measure is 10 years. If, however, low-income households face information constraints or cannot afford to move, the SEM model is less applicable. But evidence on the outflow of people from low-income coal communities suggests that people do respond to local economic/quality-of-life conditions (Partridge 2010).

Population growth is therefore a good measure of community success in countries with relatively high medium to long-term geographical mobility, such as the U.S. (Partridge 2010). People "vote with their feet" and move to places they expect will provide more satisfaction (or utility) according to their personal preferences (Faggian et al. 2012).

To take a classic American example, since the 1950s there has been a mass net-outmigration from the (relatively) wealthy Northeast and manufacturing-intensive Midwest toward relatively lower-income but warmer "Sunbelt" states (Partridge 2010). This suggests that people are trading off lower incomes to have a higher quality-of-life, or alternatively, they would require a compensating [income] differential to induce them to live in the cold Northeast and Midwest.[33]

including measures of population well-being, average income level, non-income quality of life, availability of work, dynamism and diversification of the local economy, and the local economy's integration into the larger national economy or national or global supply chains. The complexity of these aspects makes them difficult to analyze, however, especially at the county-level (Appendix C summarizes various methodologies used to understand the economic impact of coal mining and their pros and cons). Because of our community-level focus and our objective to differentiate coal transition experiences between counties, we select a relatively simple quantitative measure for which county data are available for our long period of interest. Using population growth as a metric for "success" also enables statistically robust estimates. Box 4.1 presents key examples from urban and regional economics literature and labor mobility and demography studies illustrating the use of *population growth* as the main variable to measure development.

We use a simple regression model to identify counties that over or underperformed in terms of population growth given the county's initial endowments (see Box 4.2 for description of the regression equation). We test multiple time periods for our analysis, arriving at our base model which considers population growth over the1950 to 2018 period, as well as the sub-periods 1980 to 2018

[33] If economic actors are making rational decisions consistent with an underlying utility function, then the "transitivity property" must hold across all potential migration options—for example., if migrants prefer Georgia to North Carolina and North Carolina to New York, then they must also prefer Georgia to New York. Faggian et al.'s (2012) literature review describes empirical studies that appraise whether the transitivity property holds in U.S. migration decisions; studies find that the transitivity property holds in almost all cases when assessing the migration choice set across all 50 U.S. states, meaning that net-migration reflects a rationale aggregation of people's preferences and utility functions.

Box 4.2

Methodology for identifying Appalachian counties relatively successful at transitioning from coal mining

Our dependent variable is the percent change in population between period t and *period t+j, where j depends on the time period being considered*. We estimate the following regression model:

$$\Delta population_{t,t+j} = a_0 + a_1 Mining\ Employment\ Share_t + a_2\ (Mining\ Employment\ Share_t)^2 + a_3 Population_t + Metropolitan_{1973} + NonAppalachian + Region$$

where *NonAppalachian* is a dummy variable equal to 1 if the county is in the 100-mile buffer zone outside of the ARC's region. *Region* is a vector of two region variables, ARC North and ARC South (with reference category ARC Central). Population is the log of the initial-period population, and Mining Employment Share is the initial-period share of the county's civilian labor force employed in mining. It is important to note that the mining variable includes all mining products because the exact number of coal miners is not reported for many counties due to federal confidentiality requirements—though this does not end up being a constraint for subsequent steps. The mining employment share proxies for the degree of dependence of the local county on the mining sector[35] (Appendix D provides additional details of the regression specification).

and 2000 to 2018.[34] We ranked the regression model residuals (error terms) from highest to lowest for the 99 "mining-intensive county" observations. Using population growth as the dependent variable, positive residuals are viewed as a "success" because that county over-performed in terms of population growth given initial conditions. For each period (that is, 1950-2018, 1980-2018, and 2000-2018), we considered the top one-third of the mining-intensive counties in terms of their residuals, with the largest positive residuals as potential candidates for successful transition. This resulted in 33 cases for the 1950-2018 model. And we repeated this residual ranking for the 123 counties that were "mining-intensive" in 1980, identifying the top one-third fastest growers for the 1980-2018 model; this resulted in an additional 41 potential candidate counties for successful transition.

The regression results confirm our hypothesis of a negative correlation between population growth and mining intensity in the local labor market (that is, the mining employment share takes a negative coefficient value (Appendix D Table 1).[36] This is consistent with the fact that the average population growth for the entire sample of 1,070 counties is greater than the average for coal-dependent counties, many of which experienced population loss. ARC counties significantly lagged national average population growth, and mining-dependent counties pulled

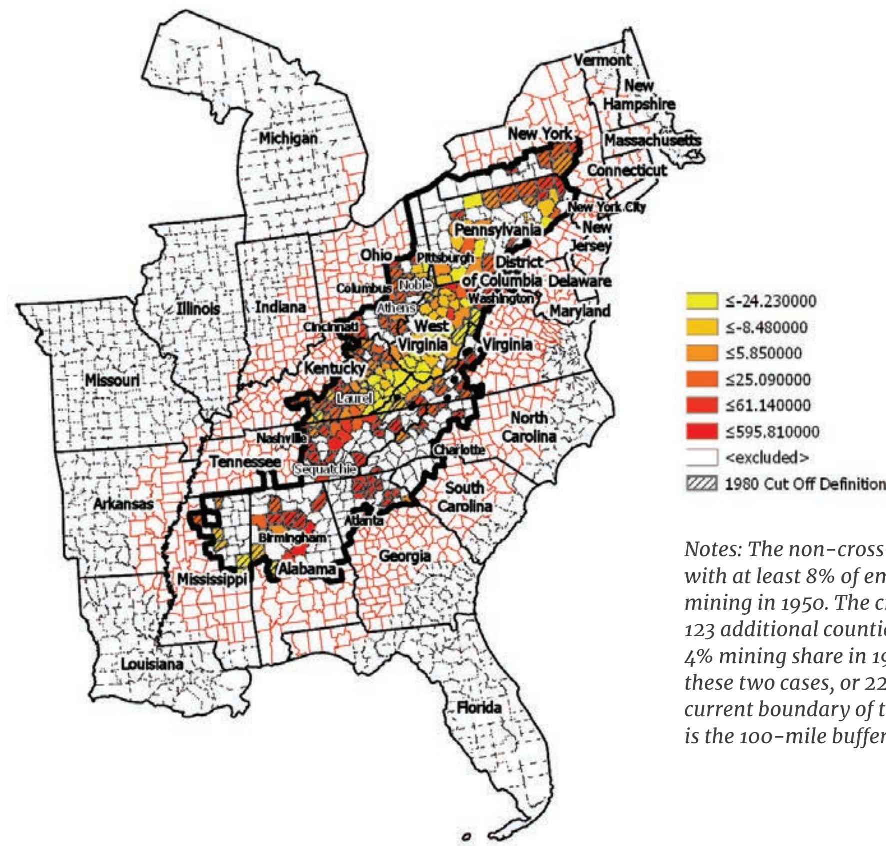
[34] We also examined population growth models, decade by decade, starting with 1950 to 1960 and finishing with 2010 to 2018, but found these redundant with the longer time-periods.

[35] We caution that these regressions are descriptive, not causal.

[36] We anticipate that, given the standard environmental, rent-seeking, resource curse and crowding-out/Dutch disease concerns about natural-resource dependent economies, the coal mining share coefficient will be negative. Other reasons to expect that the coal mining coefficient will be negative is that coal mining has been negatively linked to small business start-ups and entrepreneurship (Betz et al. 2015). Note that mining may have a nonlinear effect on local economic outcomes, which is why a mining-share quadratic term is included—in which we expect that the negative (linear) effects of mining-dependence generally begins to level off at high levels. In our modelling, we virtually always find that the quadratic mining-share-regression coefficient was the opposite sign of the linear term (which would then be positive) and statistically significant.

Figure 4.1

ARC % Population Growth over 1950-2018 for Mining-Intensive Counties



Notes: The non-cross-hashed counties are counties with at least 8% of employed residents working in mining in 1950. The cross-hashed counties represent 123 additional counties selected by having at least a 4% mining share in 1980. Figure shows the union of these two cases, or 222 counties. The black line is the current boundary of the ARC. Outside the ARC region is the 100-mile buffer of counties.

down the ARC average.[37] For the 222 counties identified as mining-intensive in 1950 (8 percent threshold) or 1980 (4 percent threshold), their average population growth between 1950 and 2018 was only 27 percent, and 95 of these 222 counties lost population (Figure 4.1).

To qualify as a "successful transition" county, we set the following criteria. The county must have:

a. been within the top-third for population growth in either the *1950-2018, 1980-2018, or 2000-2018* periods after adjusting for conditions in the regression model;

b. population growth above the ARC average (metropolitan[38] or non-metropolitan comparative averages) in at least one of the following periods: 1950-2018, 1980-2018, 2000-2018, 1980-1990, 1990-2000, 2000-2010;

[37] U.S. growth for all counties averaged 116 percent from 1950 to 2018, compared to 94.5 percent across 1,070 counties in our sample, 70 percent for the ARC counties, and 44.9 percent for the non-metropolitan ARC counties. The averages obscure some extremes. For example, McDowell County WV had the highest average 1950 mining share of 62 percent and a population loss of 82 percent between 1950-2018. In 1980, the highest mining share of the labor force was in Martin County, KY at 46 percent, and it experienced a corresponding 19 percent 1980-2018 population loss. In 2000, the highest mining shares of the labor force totaled 16 percent in Campbell County, TN, Martin County, KY, Mingo County, WV, and Wyoming County, WV, with corresponding 2000-2018 population losses of 1 percent, 10 percent, 16 percent, and 19 percent.

[38] We use the 1973 metropolitan definition, given it is in the middle of sample period.

c. eliminated, or nearly eliminated, coal employment;[39]

d. not substituted other fossil fuel extraction for coal; and

e. coal as the dominant mining activity.[40]

The pool of potential "successful" transition candidates we identified is small. Among the 222 mining-intensive counties, only 28 non-metropolitan and 4 metropolitan counties grew faster than their corresponding ARC average population growth.[42] Moreover, population growth is spatially persistent; if anything, the relative performance of the most coal-intensive areas in central Appalachia lagged further behind after 1980, and especially after 2000 (Appendix E Figures 1 and 2 present population growth maps for the 1980-to-2018 and 2000-to-2018 periods).

Based on these selection filters, four "successful" transition counties emerge. Only two counties remained after subjecting the top 33 fastest growing, mining-dependent counties in 1950 to the additional filters. And for the 41 fastest growing, mining-dependent counties in 1980, only two met all the selection criteria (despite testing for other potential qualifying counties over a range of time periods). In order of successful growth, the four "successful" coal transition counties are:

1. Sequatchie County, in S.E. Tennessee (selected from the 1980-2018 list).

2. Laurel County, in S.E. Kentucky (selected from the 1950-2018 list).

3. Athens County, in S.E. Ohio (selected from the 1950-2018 list).

4. Noble County, in S.E. Ohio (selected from the 1980-2018 list).

Figure 4.2 maps the four successful transition counties. The geographical distribution of low, median, and high-performing counties is quite dispersed across the ARC, suggesting no systematic geographic role in their selection. Sequatchie County has fully transitioned away from coal, and Athens County also appears to have fully transitioned.[43] The last year that coal employees appeared in Athens County was 2014. Laurel County's coal industry peaked in the early 1980s and mostly closed by the early 1990s, but there remains a small operation with about 10 employees. Since the late 1980s, Noble County also has had small coal operations that employ 40-50 workers (but no longer coal dependent). Noble County is the weakest case among the "successful" coal-transition counties.

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[39] We set an upper bound on the coal employment share of the labor force at less than 2 percent to signal that a county is no longer coal-dependent. In a relatively populated Appalachian mining county, that would represent a single typical-sized mine, and for a small ARC county, that would represent one small coal mine. There are no publicly-provided county data for coal employment with less than three or four coal mining companies because of confidentiality reasons. Yet, even in those cases, the Census of Mineral Industries reports a coal employment range, and other data sources report specific values. Although we cannot identify coal mining shares for the entire sample, we are able to for the success cases, enabling us to verify whether they exceeded the 2 percent coal mining employment share threshold.

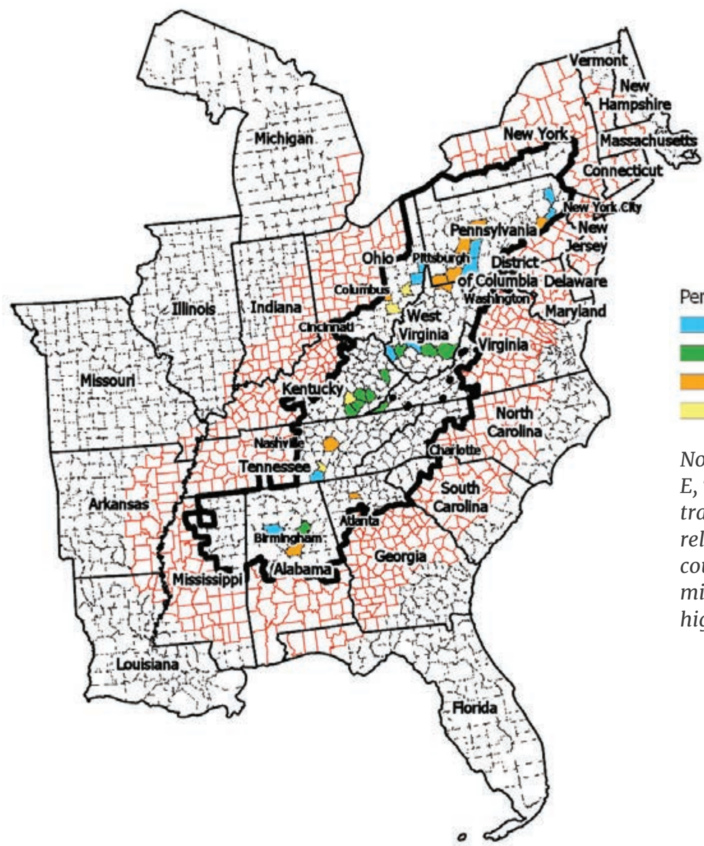
[40] We impose a threshold that at least two-thirds of the county's mining employment is in coal mining (relying on the 1954 Census of Mining Industries).

[41] The mapping is split into six equal-sized groups of 37 or 38 counties each.

[42] The 1950-2018 ARC non-metropolitan county population growth averaged 45 percent, while ARC metropolitan population growth averaged 177 percent (bottom of Appendix E Table 1)

Figure 4.2

Successful Transition and Low, Median, and High Relative Performing Counties[41]



Performance

- Worst Performing
- Middle Relative Performing
- Top Relative Performing
- Successful

Notes: The color-coding corresponds to Appendix E, Tables 2-6. Yellow denotes the four successful-transition coal mining counties, blue denotes the relatively worst-performing mining-intensive counties, green denotes the median-performing mining-intensive counties, and orange denotes the higher-performing mining-intensive counties.

Robustness Check with Other Measures of Success

We test the robustness of our selection methodology by comparing our results to other variables commonly used to measure successful post-coal economic development.

To do this, we compare our four "successful transition" counties to other mining-intensive counties with respect to key indicators associated with well-being: population growth rate, mining and coal employment shares, median household income, and poverty. With only four successful coal transition counties, it is impractical to conduct a standard analysis

[43] The sources for this coal mining information on the four success stories are:

(1) 1954, 1977, 1982, 1987, 1992, 1997, 2002, 2007, 2012, 2017 Census of Mineral Industries,

(2) Kentucky Coal Facts, various years but especially the 16th edition in 2017, (available at: https://eec.ky.gov/Energy/News-Publications/Pages/Coal-Facts.aspx. downloaded May 5, 2020).

(3) 1993, 2000, 2017, and 2018 Ohio Mineral Reports. (available at: http://geosurvey.ohiodnr.gov/news-events/recent-news-events-and-features-archive/post/2018-mineral-industries-report. Downloaded May 5, 2020).

(4) Mining Health Safety Administration CY 2009-CY 2015 Coal Mining Employment by state and county. (downloaded from: https://www.msha.gov/sites/default/files/Data_Reports/Charts/Coal_Employment_by_State_and_County_CY09to15.pdf. Accessed May 7, 2020.)

of statistical correlations; we therefore use descriptive analysis to compare outcomes of our four counties to the top-10, median-10, and bottom-10 ranked performers (based on population growth) within the 99 mining-dependent ARC counties[44] (results in Appendix E Tables 1-4).

Of the four coal-transition success stories, only Sequatchie County, TN is a metropolitan county, part of the Chattanooga metropolitan area since 1973. Thus, urban-led growth is not the reason for the other three counties' successful transition. Sequatchie and Laurel Counties both experienced relatively rapid population growth. Laurel County's growth roughly tripled the nonmetropolitan average ARC population growth rate between 1950-2018, and exceeded the ARC average during every period. Sequatchie County slightly trailed the average ARC metropolitan rate, but exceeded it in the 1970s. By the 1990s, its population was growing faster than the ARC average (see Appendix E for further detail on robustness analysis of "successful" counties).

It is notable that these successful counties transitioned at different times:

- **Laurel County** was an intermittent coal producer, with heavy production during 1940-1960 and 1970-1988, after which its coal production was small. The county transitioned from coal dependence around 1990.[45]
- **Sequatchie County's** coal dependence ended in the mid-1980s as the share of employees in mining declined. This coincided with the 1980s coal market bust, and increasing economic diversification as the county became more integrated with Chattanooga. Like Laurel County, Sequatchie County experienced relatively rapid growth while still coal dependent, and transitioned away from coal by the early 1990s before large-scale coal production ceased.
- **Athens County's** average population growth rate was slightly below the ARC's 1950-2018 non-metropolitan average, but exceeded the ARC average in four of seven decades. Between 2000-2010, its 3.8 percent population growth was between the U.S. nonmetropolitan average of 3.5 percent and the ARC's average of 4.5 percent. While not booming, Athens County has experienced steady growth. It had a moderate-sized coal industry in the 1950s, but its coal industry was very small by the early 1960s and disappeared after 2009.
- **Noble County** generally underperformed ARC non-metropolitan population growth rates from 1950 to 2018, but greatly over-performed in the 1990s. From 2000 to 2010, Noble County's 4.2 percent population growth was between the U.S. and ARC nonmetropolitan averages. Noble County still has a small coal mining sector employing about 40-60 workers since the mid to late 1970s (*Census of Mineral Industries and Ohio Mineral Report*). Noble County also has had a small oil and gas industry during high-drilling periods. Having more intensive-coal mining neighbors such as Belmont County, Ohio means that some Noble County residents commute elsewhere to work in mining, mainly in oil and gas but also coal. This explains why Noble county's

[44] We use the 1950-2018 model's 99 regression residuals to determine the included counties. We select this model because it indicates long-run success and we have already shown strong spatial persistence in population growth over the 1950-2018.

[45] Source: op. cit. Kentucky Coal Fact Book, 2016.

place-of-residence mining share of the labor force is higher than anticipated given its small local mining/coal employment levels. Therefore, while we include it as a "successful" case of transitioning from coal, it is a marginal example. After the energy bust in the early 1980s, Noble County was less exposed to the energy industry, and coal in particular. Thus, it appears to have transitioned from coal about a decade before the relative prosperity of the 1990s and early 2000s. Nonetheless, Noble County did not fare well after the 2008 Great Recession.

Taken together, our results indicate that after eliminating over 98 percent of mining-intensive county candidates, the four selected counties are *relatively* successful. The four successful transition counties experienced much faster average population growth than many counties. Yet, the successful counties modestly trailed the top-10 performing mining-intensive counties between 1950-2018. This is partly explained by outliers Shelby County, AL, part of the Birmingham metropolitan area, and Pickens County, GA, which has experienced rapid amenity-led growth. The four successful counties grew faster than the 10 median-performing counties that continued to be mining-dependent and especially the 10 worst -performing counties, which experienced declining populations between 1950 to 2018. Since 1990, the four successful transition counties have experienced slightly faster average growth than the top-10 cohort, suggesting that the benefits of transitioning away from coal are increasingly paying off.

The four successful transition counties had above average mining shares compared to the ARC region until 1990, after which their shares fell (Appendix E Table 2). The top-10 fastest growing, mining-intensive counties tend to have had higher mining shares than the four successful counties (except in the 1980s), although the gaps became small beginning in the 1990s. Not surprisingly, sector diversification away from mining is associated with economic prosperity—although the top-10 performers are skewed because 5 of the 10 counties became metropolitan by the end of the sample period. Until 2000, median-performing, mining-intensive counties had higher mining-shares than either the relatively successful transition counties or the top-10 performing mining-intensive counties, after which their mining shares converged. The bottom-10 performing mining-intensive counties exhibit a surprising pattern; their mining-shares converged to near the four successful transition counties by 1970, and afterwards maintained mining shares either equal to or below the four successful transition counties. One possible explanation is that the underperformers include metropolitan counties that had both coal and complementary manufacturing in the mid-20th century—for example, integrated steel mills. After these manufacturing industries failed in the face of foreign competition and technological change (for example, shifting from integrated steel to mini-mills), the economic drivers of these small industrial cities dissipated, leading to depopulation and declining coal demand.

Factors Underlying Successful Coal Transition

Why were the four counties successful? In this section, we explore factors most likely to have contributed to their success, based on variables that social scientists typically associate with local economic development. Some of these factors appear to correlate with successful economic transition, but others play little role in the Appalachian context. Our results are based on descriptive quantitative data for the 99 mining-intensive Appalachian counties, using the same comparison categories as the prior section—that is, top-10, median-10, and bottom-10 performers in terms of population growth.

Human Capital

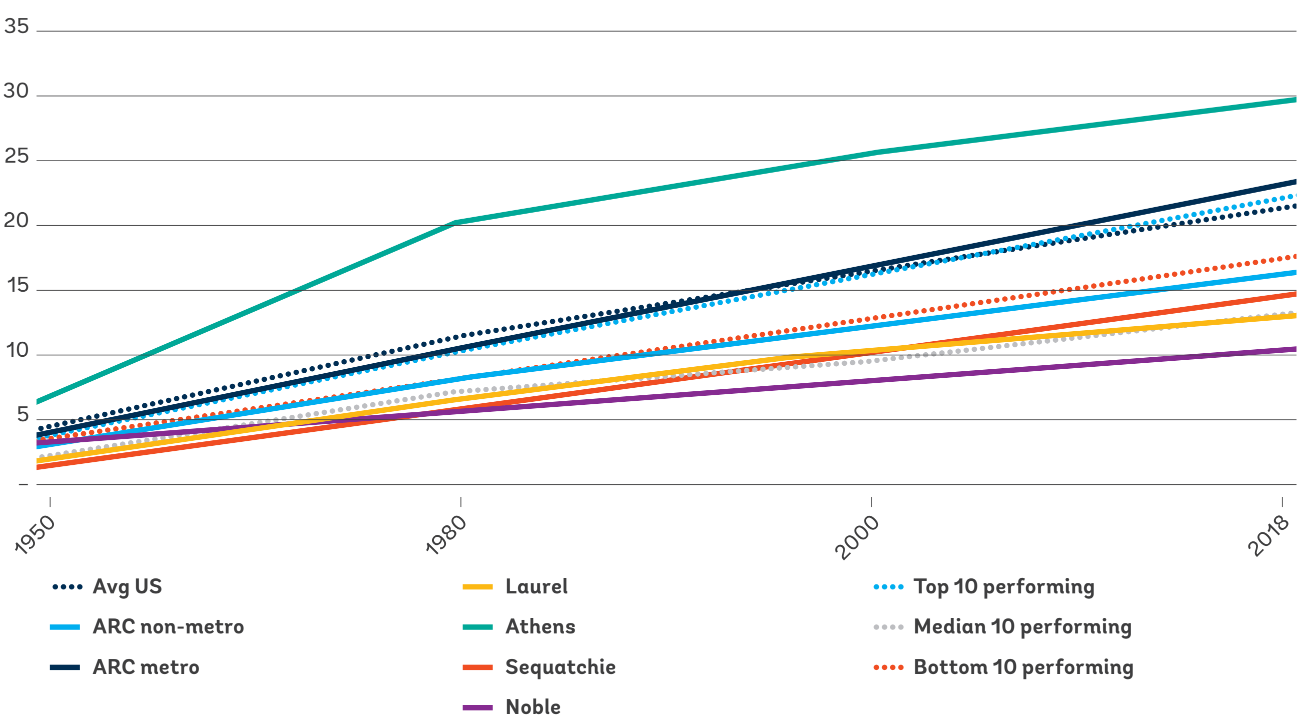
The four successful coal mining transition counties had average educational attainment levels within ARC but below national averages. Further, this performance is skewed upward by the relatively strong performance of Athens County, home to Ohio University. Table 5 in Appendix E shows the average share of the over-25 population with at least a Bachelor's degree (CG), some college including an Associate's degree (SC), and high school graduates (HS) for 1950, 1980, 2000, and 2018. Besides Athens, tertiary educational attainment is generally low in the other three successful transition counties, especially the college graduate shares, which are well below the US average (Figure 5.1). The top-10 performing mining-intensive counties also have a skewed educational profile. For example, Monongalia County, WVA, home to West Virginia University in Morgantown, significantly increases that category's average education. High state investment in university settings is hard to replicate. Based on these relatively mixed results, with the exception of Athens County, we conclude that educational attainment in itself does not explain why the counties had relative success in transitioning away from coal.

Sectoral Composition and Diversification

The underlying structure of local economic production affects the types of jobs available and productivity levels. By comparing the 1950 pre-transition economic structure of mining counties across the ARC region, we may detect variations that have helped some

Figure 5.1

Share of College Graduates (% of over-25 population)



Source: Author calculations using U.S. Census Bureau's Decennial Census of Population (various years).

counties diversify. Appendix E Table 6 reports the employment shares for the agriculture sector, manufacturing, and self-employment in 1980, 2000, and 2018 to show patterns that might explain the relative successful performance of the four coal-transition counties.

Farming. Farming can have mixed economic effects. On the positive side, agriculture cannot be offshored and can be a source of new entrepreneurship. However, a degree of import substitution together with labor-saving productivity increases have led to fewer farm jobs. Farming's share of total U.S. employment was 41 percent in 1900, 21.5 percent in 1930, 4 percent in 1970, 1.9 percent in 2000, and just over 1 percent in 2019 (U.S. BLS; Dimitri et al. 2005). Heavy reliance on farming is unlikely to offset declining coal mining employment. The four successful transition counties all had relatively large average shares of agriculture employment in 1950, averaging 32 percent, larger than the 1950 ARC non-metro farm share, and considerably greater than the other comparison counties. Consistent with the national trend, average farm employment shares fell in all four performance categories after 1950, becoming relatively insignificant today.

Manufacturing. A large manufacturing sector typically raises average productivity and wages compared to resource or service-based economies. Manufacturing has long been considered key for rural development, especially during the mid-20th century. U.S. Bureau of Economic Analysis (BEA) data indicates that beginning in the mid-1970s, rural-based manufacturing grew relatively faster than in metropolitan areas, and had a higher share of manufacturing employment thereafter. Whereas the four successful transition counties had much lower manufacturing shares in 1950 (averaged 11 percent) compared to other coal-intensive counties, manufacturing sectors in our "successful" counties increased rapidly after 1950, peaking in 1980-2000. Meanwhile, the other three mining-intensive categories—and in fact much of the U.S.—were experiencing deindustrialization. The exception was Athens County, OH, where economic transformation centered around Ohio University. After 2000, however, manufacturing intensity in the four successful transition counties fell sharply, in line with regional and national trends. Moreover, the future prospects of "reshoring" manufacturing from abroad faces stiff headwinds, given established and highly efficient global supply chains that rely on low-wage countries for labor-intensive production. Even the COVID-19 pandemic and attendant pressure on global trade is unlikely to significantly realign manufacturing toward the U.S. Relying on new manufacturing to replace coal-mining going forward is risky, and additional costs are associated with Appalachia due its remoteness from suppliers and customers.

Self-Employment. Within highly developed economies like the U.S., higher self-employment[46] intensity tends to be associated with faster economic growth, larger multiplier effects through locally-based supply chains, and profits retained locally, all of which support local growth (Stephens and Partridge 2011; Stephens et al. 2013; Tsvetkova et al. 2019). High levels of local entrepreneurship can help make local communities more resilient to economic shocks. Stephens and Partridge (2011) find

[46] Self-employed workers are defined as those who own their own firm as either a pass-through (income) business, S corporation, or partnership. These firms can employ other workers. A large share of firms start as self-employed, but as they grow, there are legal advantages to become a C corporation—e.g., they can be publicly traded on financial markets.

that greater shares of self-employment support growth in the ARC region. The four successful transition counties exhibit quite high shares of self-employment, averaging 33 percent in 1950 and sustained average self-employment rates throughout the adjustment period relative to the top, median, and bottom-performing, mining-intensive counties (note that Athens County is an outlier). While based on a small sample size, these results point to potentially using local assets and capacity to promote small-business development to counteract declining coal employment.

Population Demographics

Population age structure affects current and future economic growth. In particular, the "dependency ratio"—that is, the share of children and senior citizens in a household—reflects the population share not contributing to economic production and at least partially dependent on local government for education or services, including healthcare. A larger share of children can support future growth once they enter the local labor force, whereas a larger share of seniors may increase the local fiscal burden.[47] The age structure and trends in Appalachian coal counties do not vary significantly from national patterns (Appendix E Table 7 reports population shares for those under age 18 and over 65). The four successful coal-mining transition counties exhibit similar patterns to the rest of the ARC region, suggesting that demographic-age structures do not explain the relative success of these counties.

Geographic Characteristics and Agglomeration Economies

We look at several geographic characteristics that commonly affect local economic growth: extent of urbanization, proximity to metropolitan areas, agglomeration economies, natural amenities, and topography. We also look at sociodemographic factors such as inequality, unemployment, and race (summarized in Appendix E Table 8).

Urbanization. The degree of urbanization is positively correlated with economic growth rates, but this is not systematically borne out in the data for Appalachia. Based on the 2013 USDA rural-urban codes (RUC) methodology,[48] which assigns a value of "1" to the most urban, and a value of "9" to the most rural, we find that

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[47] There can be positive returns to large retired populations, e.g., in destination retirement markets such as Arizona, the far south Atlantic states and Gulf Coast states, where local economies can be boosted by attracting sufficient numbers of (wealthy) retirees. In Appalachia coal-country, however, we do not observe a pattern of senior citizen wealth inflow that offsets the fiscal burden, not least because degraded environmental conditions do not attract in-migration.

[47] The 2013 RUC codes are defined below with more details from the USDA, available at: https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx, downloaded on July 17, 2020.

Metropolitan Counties

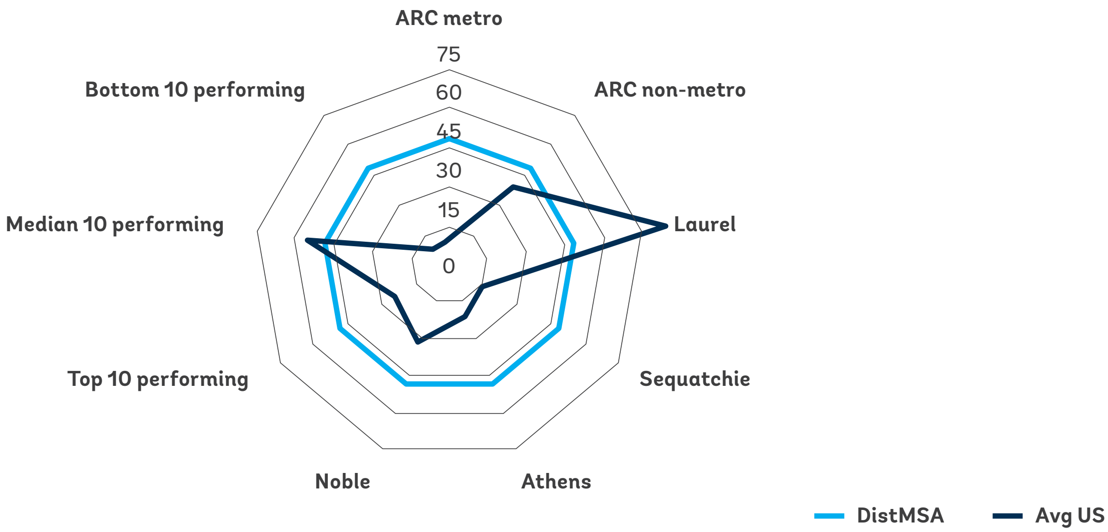
Code	Description
1	Counties in metro areas of 1 million population or more
2	Counties in metro areas of 250,000 to 1 million population
3	Counties in metro areas of fewer than 250,000 population

Nonmetropolitan Counties

4	Urban population of 20,000 or more, adjacent to a metro area
5	Urban population of 20,000 or more, not adjacent to a metro area
6	Urban population of 2,500 to 19,999, adjacent to a metro area
7	Urban population of 2,500 to 19,999, not adjacent to a metro area
8	Completely rural or less than 2,500 urban population, adjacent to a metro area
9	Completely rural or less than 2,500 urban population, not adjacent to a metro area.

Figure 5.2

Distance to Metropolitan Areas (miles)



Source: Author calculations using U.S. Census Bureau's Decennial Census of Population (various years).

Appalachia's non-metropolitan counties are more rural than the national average, and the four successful counties are even more rural than other mining-intensive counties. This result suggests that lack of urbanization did not impede their relative success.

Proximity to metropolitan areas. Rural communities close to metropolitan areas grow faster due to greater access to urban labor markets for commuters, urban services for households, and urban markets for firms (Partridge and Rickman 2008; Partridge and Olfert 2011). To assess how much of the relative "success" of the four transition counties is due to proximity to urban areas, we consider the distance from the population-weighted centroid of the county to the population-weighted centroid of the nearest metropolitan area.[49] While closer than the average U.S. county and the ARC non-metropolitan county average, three of the successful transition counties are actually farther away on average than the top-10 performing mining-intensive counties (Figure 5.2; details in Appendix E Table 8). This implies that urban access is unlikely to have played a tangible role in the transition of the four successful counties.

Agglomeration. Lack of agglomeration economies represents an impediment to economic development in lagging U.S. regions. Agglomeration effects include cost-saving efficiencies from economies of scale and network effects that arise from urban agglomeration, namely when firms are located near to each other. Many rural under-developed regions lack the population size

[49] The source of the DISTMSA variable is author calculations using the STATA statistical software and U.S. Census geocoding for county centroids.

to sustain a critical mass of producer and consumer services to support growth. To understand whether urbanization supported our successful transition counties, we consider their population levels (Appendix E Table 9). The four successful coal transition counties are all sparsely populated, with a 2018 average population of 38,800. The median-performing counties are also small with an average 2018 population of about 34,800. Surprisingly, the top-performing and bottom-performing mining-intensive counties are more populated, with 2018 populations averaging over 90,000. This pattern seems to contradict the tenet that agglomeration economies are a major determinant of local economic growth. The finding is nevertheless encouraging because it suggests that relatively unpopulated coal-mining communities can transition without devastating economic consequences.

Natural Amenities. The U.S. Department of Agriculture (USDA) Economic Research Service calculates the level of natural amenities at the county level based on the presence of "warm winter, winter sun, temperate summer, low summer humidity, topographic variation, and water area."[50] This amenity index uses a one-to-seven scale, seven indicating the most amenities. Partridge (2010) reviews the literature to show that a nice climate and pleasant landscape attracts migration, with (net) moves toward warm winters, mountains, lakes, and oceans. For the four successful transition counties, their average level of natural amenities measures 3.5, which is quite similar to Appalachian comparator counties and to the entire U.S. Despite the implied small variation in natural attractiveness, the degree to which counties leverage their natural amenities, such as for tourism, may affect their transition success. The county case studies presented in section 6 below examine this aspect in more detail.

Topography. Topography matters for economic development. Mountains can attract migrants and tourists, for example, but can also impede access and complicate construction of buildings and physical infrastructure. Unlike the Western U.S. mountains with their typical wide valleys, Appalachia's mountain terrain tends to lack level land. Using the USDA's TOPO[51] index scale, which ranges from 1 (flat) to 21 (most mountainous), the ARC region ranks over 15 on the scale, compared to a national average of 9. But the four successful transition counties have an average topographical score of 17.7. This is similar to other mining-intensive counties, suggesting that topography was not a contributing factor to their relative success.

Inequality. Household income inequality, as measured by the Gini coefficient (where "zero" reflects perfect equality and "1" is perfect inequality) is very similar across the entire ARC region and national sample. This suggests that differences in inequality and its associated negative social effects are not a determinant factor for successful transition from coal.

Unemployment. Unemployment rates (2018 data) are slightly high across the ARC region, but consistent with the trend of higher unemployment rates in less-populated counties. There are otherwise no discernable differences between the four successful transition counties and other mining-intensive counties.

Race. Finally, the minority share of the local population can be an important socioeconomic

[50] The source of the AMENTIY measure and details in its construction are available from the USDA at: [https://www.ers.usda.gov/data-products/natural-amenities-scale/] downloaded on July 17, 2020.

[51] See the source of the AMENITY measure for details on the TOPO index.

indicator commonly correlated with lower human capital and lower incomes. Rural ARC counties are heavily white, with no clear differences across the mining-intensive counties. This suggests that race does not explain different long-term economic effects in the four successful transition counties.

Social Capital

Social capital, defined as "norms of trust, reciprocity, and networks of relationships existing within local communities",[52] tends to lubricate economic activity and the ability to collectively organize to improve socioeconomic well-being (Audia and Teckchandani 2010). Social capital makes basic market transactions easier as more trust implies less need to draw up complex contracts or to monitor the behavior of economic parties. Social capital also facilitates common community efforts through enhanced cooperation and trust that all parties are working for the same goal. Researchers have pointed to the importance of social capital in increasing community resiliency in the wake of disasters and downturns (Aldrich and Meyer 2015). In terms of economic development, social capital increases the cooperation necessary to support and promote new local investment and the likelihood of institutional support for winners compensating losers (Reese and Rosenfeld 2002; Woolcock 1998).

Yet social capital may have unintended or counterproductive consequences (Putman 2000; Woolcock 1998). For example, while high social capital may bind local residents together in close-knit communities, these residents may lack "bridging" social capital that connects them with outside communities and their innovative ideas. An illustration of this is when residents in a small town are skeptical of outsiders and do not integrate them.

Social capital cannot be directly measured, so we use proxies. For example, researchers often use the proportion of the population that engages in various local associations, votes, or voluntarily responds to the Census. The common theme of these proxies is that people engage in behavior that may have little individual benefit but can advance community interests or serve a public good (Rupasingha et al. 2006). Social capital measures considered here are drawn from Rupasingha et al. (2006).[53] Appendix E Table 10 presents the following county-level social capital proxy values:

- Total number of religious, civic, business, political, professional, labor, and recreational establishments per 1,000 residents (ASSN2014).
- Voter turnout in the 2012 general election (PVOTE2012).
- 2010 Census household response rate (RESPN2010).
- Number of non-profit organizations including those with an international approach (NCSS2014).
- A composite Social Capital Index (SK2014).[54]

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[52] Putman 2000.

[53] Social capital data is from https://aese.psu.edu/nercrd/community/social-capital-resources.

[54] The Social Capital Index SK2014 is standardized across all US counties, such that it has a mean of zero and standard deviation of 1. Negative numbers reflect below-average social capital and positive numbers reflect above-average social capital.

While social capital may change over time, it tends to be persistent at the local level. If we believe that higher social capital positively correlates with local economic development, as the literature posits, then we might expect these factors to facilitate transition from coal mining.

Strikingly, throughout the ARC region, in both mining- and non-mining-intensive counties, overall social capital is below the US average. This may help explain why ARC counties lagged even prior to coal transition. Lower social capital may also impede transition given the lack of bridging capital to connect with outsiders. The four successful transition counties exhibit social capital levels broadly in line with their ARC neighbors. With the exception of Noble County, they underperform the US average across the range of proxy indicators. As measured by traditional social capital proxies, therefore, we find no strong link between social capital and the successful transition of coal-dependent counties.

Government Capacity

Economic development literature posits a link between local government capacity and economic well-being, although there are few quantitative studies. Lobao et al. (2014) find that U.S. county governments with greater institutional capacity tend to be more active in social and business policy formulation and provide more public services. Local fiscal resource autonomy is expected to make local governments more accountable to civil society and more motivated to improve services (Pöschl and Weingast 2015). Localities able to raise greater revenues tend to face lower barriers to improving conditions (Johnson et al. 1995). Local government spending and fiscal pressures (such as large fiscal deficits) are often used as indicators of capacity (Sharp and Moody 1991). Public spending can create economic multiplier effects, reduce economic instability, improve infrastructure, and produce goods and services for local populations (Allard 2017). Fiscal pressure, by contrast, can deter government investment in activities needed to create growth and local well-being (Johnson et al. 2015).

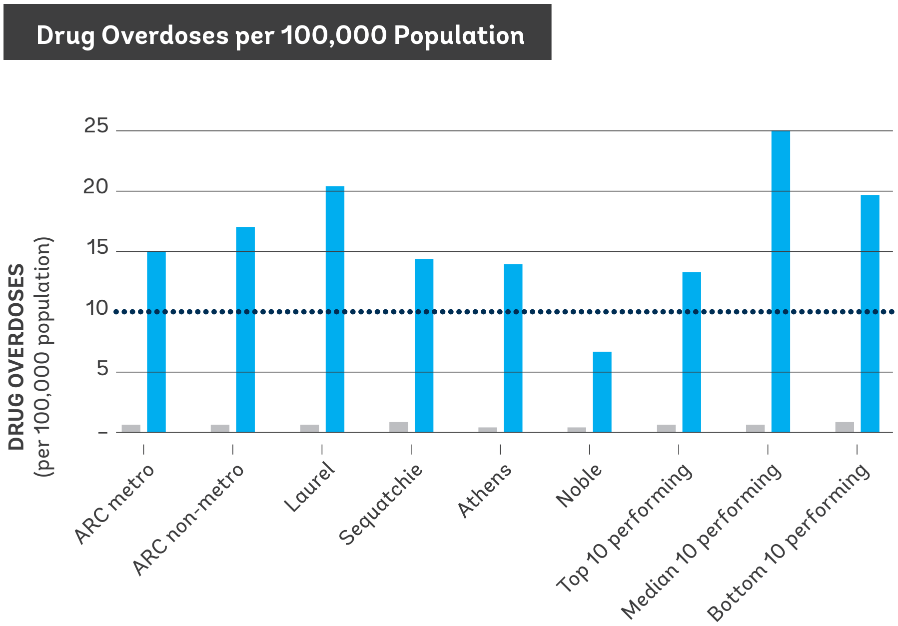
Overall, local government capacity in the four successful transition counties appears broadly similar to the ARC region (Appendix E Table 11). On average the four successful transition counties raise about half of their revenue locally, similar to the top-10 performing mining intensive counties. With the exception of Athens County, they tend to experience slightly less fiscal pressure compared to other counties.[55]

Health Outcomes

The four successful counties compare well to national and regional health outcomes, except in deaths by drug overdose. Health outcomes tend to be better in communities with more social capital and fiscal capacity, and thus indirectly correlate with economic growth. Moreover, the availability of local economic opportunities may further reduce "deaths of despair", such as drug overdoses and suicides. We therefore consider the mortality rate as a proxy for the effectiveness of local social capital and government capacity to support better quality of life.

[55] U.S. counties are required to balance their budgets annually so a close association between revenues and expenditures is to be expected.

Figure 5.3



Source: Author calculations using data from the Institute for Health Metrics and Evaluation (IHME).

Mortality: National life-expectancy in 1980 averaged 73.8 years, slightly higher than the ARC region. By 2014, longevity had increased to 77.8 years nationally, consistent with the top-performing coal-intensive counties and four success stories, but higher than the ARC non-metropolitan average of 76.0 years (Appendix E Table 12). With respect to other mortality indicators—such as death by suicide, alcohol poisoning, or violent acts—the four successful transition counties performed better than U.S. and ARC region averages, with one key exception: drug overdoses. It is notable that in all other "deaths of despair" categories, the successful transition counties—and in fact much of the Appalachia region—performed better than the national average, a surprising outcome given their remote rural locations.

Opioid Epidemic: The Appalachia region has been severely affected by the opioid epidemic, and includes some of the most afflicted counties nationwide. By 2014, ARC metropolitan and non-metropolitan counties saw drug overdose death rates of 15 and 17 per 100,000 population, respectively, a sharp increase from 0.7 in 1980 (Figure 5.3). Overdose deaths were particularly high in the 10 middle-performing counties, where the rate averaged 31/100,000.[56] The four successful transition counties had slightly lower rates (averaging 13.8/100,000), although still nearly 40 percent above the U.S. average. Laurel County, KY, had an alarmingly high overdose rate of 20/100,000, twice the national average. Nobel County, OH, by contrast, posted a much lower overdose rate, long life expectancy (81 years), and above average performance in other health-related indicators.

[56] This group includes Floyd County, KY (47.7/100,000), Leslie County, KY (44/100,000), and Whitley County, KY (35.4/100,000).

A Closer Look at Successful Transition: County Case-studies

In this section, we present case-study analysis of the four successful transition counties in Appalachia, and one case-study from outside the region. We describe the types of opportunities and resources available within each community that likely contributed to its relative success in transitioning from mining-dependence. It is notable that all four counties increased their coal activity during the mini-coal boom in the late 1970s and early 1980s before ultimately reversing course. The factors discussed here do not explain the decline of coal activity, but rather provide insight into the post-coal economic recovery. We focus particularly on the role of distance and road infrastructure, local industries beyond mining, institutional capacity, and social capital networks. For comparison, we also present a case study of successful transition by a resource-dependent county outside the ARC region to explore common factors. We end with a discussion of the cross-cutting economic benefits of the Appalachian Development Highway System.

Information about the counties comes from primary sources through key informant interviews,57 quantitative population and survey data58, and secondary data sources such as official government websites, published reports, and media articles. Given the current COVID-19 pandemic, locating and contacting individuals proved challenging, especially in Sequatchie, as its website is limited and out of date. We asked informants a series of questions about factors affecting their county that could help explain the transition (for example, distance/infrastructure issues, local economic structure, population characteristics, institutions/government, and social capital networks such as collaboration within the county and with outside entities).

Athens County, Ohio

Athens County, Ohio, the first community that successfully transitioned from coal mining, began its transition in the late 1950s and early 1960s, when the coal mining share of the labor force fell below 2 percent, and ultimately fell to zero. Its population of 54,889 persons in 1970 grew to 65,936 by 2018, during which time mean household income rose from $56,889 to $76,771 (constant $2018). Despite these income gains, the household poverty rate increased from 13 percent in 1970 to 17 percent in 2018. As of 2017, the county's main sectors of employment were educational services (28 percent of employed residents), healthcare and social assistance (12.9 percent), and retail trade (11.4 percent) (Data USA 2020).

The story of Athens County's success appears to be heavily tied to the presence of a public university within the county. Athens County is home to Ohio University, a public, four-year college; Hocking College a public, two-year college; and an Ohio Technical Center. Ohio University's rising enrollment more than doubled from about 8,000 students in 1960 to over 19,000 by 1970. In the course of our case-study work, we interviewed Dr. Jason Jolley, Professor of Rural Economic Development and Director of the Masters of Public Administration at Ohio University. His summary of Athens County's transition from coal employment is as follows:

> "Brick-making from clay and coal mining were two major employers in Athens County historically. However, after World War II there was growth in the city of Athens [the county seat], as the GI benefits led to influx of enrollment at Ohio University (OU) that then lead to the campus boom and growth. This is also about when Athens County saw its decline in coal employment, and again with the Vietnam War. Those are the two periods of growth in the county, and that was largely driven by enrollment at the university. Simultaneously, technological advances in the 1950s and 60s opened up new areas of coal mining, that required less employment in coal. So, the story is that the University (OU) drove the economic diversification, and then the technological changes made it easier to get to coal, allowing for decline in coal employment (Jolley 2020)."

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[57] We selected informants through a search of county government websites, federal/state/county-funded Extension Service offices (agents who provide development assistance to counties), and library and media outlets. We also asked each key informant to recommend other knowledgeable people. The key informants include county commissioners, mayors, Extension agents, local business people, Chamber of Commerce, directors of public-private economic development associations, local librarians, and researchers.

[58] Decennial U.S. Census, the American Community Survey (ACS), and other secondary sources provide county-level data on socioeconomic well-being and other conditions over the past half century (1950-2018).

The nexus of the university, the ARC's regional economic development district (Buckeye Hills Regional Council), and small businesses and nonprofits within Athens county reflects a high degree of administrative institutional capacity to pursue economic development strategies and diversification (Jolley 2020). These development partnerships have benefited Athens County: Mike Jacoby (President of the Appalachian Partnership for Economic Growth) noted that a number of new companies "grew out of the university—Global Cooling, Quidel (formerly Diagnostics Hybrids), and RXQ Compounding—... [these] came out of the university business incubator or because of the university talent." Further, cross-county partnerships resulted in a retraining program administered by the Hocking-Athens-Perry Community Action Program (HAPCAP), which helped miners and their spouses obtain decent-paying jobs elsewhere after the last coal mine in the area closed in 2002 (Harris 2020). Athens has been active in securing ARC funding, and developed innovative ARC projects, such as those that provide philanthropic support and programs for youth, some of which use local campus space (ARC 1999). Recent ARC Power Grant funding data shows that the county received 7 grants out of a total 23 received by Ohio counties (ARC 2020).

Ohio University also contributes significantly to social capital in Athens County. Dr. Jolley noted the strong base in the county/city of Athens because of Ohio University, which motivates the community's greater willingness to invest in the arts, community events, and local culture. Additionally, there is greater support for and investment in local businesses and the local food system. Finally, due to the University, the population in Athens County is more politically liberal than other counties within Ohio's Appalachian region. Dr. Jolley linked this political liberalism with greater focus on promoting environmentally sustainable practices and concern about the negative impacts of coal mining. For example, in partnership with Ohio University, Athens County received an Environmental Protection Agency (EPA) water stream restoration grant to clean county streams degraded from coal waste.

Location and natural amenities have also played a role in Athens' success. Athens has had easy access to its nearest major metropolitan area, Columbus via U.S Route 33, which was constructed in 1938 and runs through the county. Between Athens' County seat (also named Athens) and the Columbus I-270 beltway, US 33 is mostly four lanes, much of limited access. The county is also home to some recreation and tourism amenities such as Wayne National Forest.

Noble County, Ohio

Noble County, Ohio, began its transition before 1980, when the coal mining share of the labor force fell below 2 percent. Nobel County's population was 10,428 in 1970 and increased to 14,443 by 2018, during which mean household income rose from $51,231 in 1970 to $73,906 in 2018 (constant $2018), and the household poverty rate fell sharply from 20 percent in 1970 to 9 percent in 2018. The principle sectors of employment in 2017 were healthcare and social assistance (16.9 percent), manufacturing (14.1 percent), and retail trade (12.8 percent) (Data USA 2020).

Noble County benefitted significantly from the building of a state prison in the area. We interviewed the retired Community

Development Director of Noble County Extension, Edwin Lloyd, who served the county during the transition period. When asked about what contributed to the county's move away from coal, former Director Lloyd said:

> "A brief sketch of Noble county first includes the surprise that Noble has consistently grown, because it is still one of the smallest counties in the state in terms of population. However, as to how the county has achieved that – in the 1960s the interstate was built through the county (I-77) and it created an opportunity for the county to develop at least a little as a bedroom community for other counties in the region with more employment opportunities, and as a result most of the residents work outside of the county. The main real change that happened was when the state prison (the Noble County Correctional Institution) was opened in the county in 1996. The prison employs 396 people, which contributed to Noble County's growth during the period.[59] The facility has a population of just under 2,500 inmates, and they would also be included in the population of Noble County under the US Census "group quarters." As to how the prison came to be located in the community – some groups, such as county commissioners and state legislatures, worked together. The county bought the land and then gave it to the state to build the prison. However, to some degree it was luck that the prison was located in Noble County, but it remains a major employer in the county (Lloyd 2020)."

Manufacturing provided another pathway for the county's economic diversification. One example is the Mahle Engine Plant – still operational when Noble County began transitioning away from coal employment. According to Gwynn Stewart, current development director of County Extension, the plant provided some good local jobs. In terms of current economic development opportunities, Director Lloyd noted that although Noble County, along with other counties in the region, have benefited from manufacturing plants since the decline of coal mining, many factories have since closed and moved abroad, where production and labor costs are lower. The community has not in fact entirely abandoned coal; B&N Coal still has a small operation in Noble County today.

Geography has had some positive impact on diversification and growth but also creates challenges. Interstate-77 passes through the county, allowing residents to commute elsewhere. Wayne National Forest is also located in parts of Nobel County, attracting tourism and recreational activities. But lack of infrastructure limits the ability to recruit and expand industries within the county. Former Community Development Extension Director Lloyd noted that water and sewer systems are limited and would likely be unable to support large-scale development, and cellphone and broadband services remain limited due to the county's mountainous terrain.

Noble County's record on social capital networks and collaboration is mixed. The Noble County Chamber of Commerce website indicates that its development efforts began formally in 1971, and that collective efforts have been ongoing. As noted, county groups had worked with the State Legislature to bring a prison to the county. Nevertheless, there are

[59] Prison data from the Ohio Department of Rehabilitation and Correction, [downloaded from: https://drc.ohio.gov/nci. on May 19, 2020].

many challenges to the community's economic wellbeing, according to Director Lloyd, such as the lack of non-governmental organizations and agencies that promote economic development. For example, he stated regional partners like United Way were not present, and basic social services, such as a homeless shelter or emergency medical services, are limited or nonexistent. An initiative to support small business development through loans was abandoned because the program was undersubscribed. Noble County has successfully collaborated with other counties to obtain ARC funding for "innovative" grants projects (ARC 1999), and had received two ARC POWER grants by 2020.

In short, Noble County's economic development limitations persist. While the county benefitted from securing a state prison, and while its population has grown as mining declined, it continues to struggle with small size and limited infrastructure.

Laurel County, Kentucky

Laurel County, Kentucky, made its post-coal transition between the late 1980s and the 1990s (after increasing its coal dependence during the late 1970s/early 1980s coal boom). It's 1970 population of 27,386 more than doubled by 2018 to 60,180. Mean household rose from $40,193 in 1970 to $60,981 in 2018 (constant $2018), while household poverty rates fell from 34 percent to 19 percent in the same period. By 2017, the main sectors of employment were retail trade (15.4 percent), manufacturing (13.9 percent), and healthcare and social assistance (12.9 percent) (Data USA 2020).

The primary driver behind the growth of Laurel County and its capital (City of London) into a regional hub was the construction of two major roads, according to the City of London's Tourism Office. Interstate 75 (I-75), which runs north/south, opened in 1969, and Highway 80, which runs east/west and is known as Hal Rogers Parkway (formerly Daniel Boone Parkway), opened in 1971. Other communities east of Laurel County did not have the advantage of the new interstate, whereas most of the counties along that corridor have seen progressive growth. Other infrastructure investments also helped facilitate economic development. The regional London-Corbin Airport was established in the early 1970's; whereas it has no scheduled airline passenger flights, it is among the five busiest airports in Kentucky.

Investments made to pipe water from Laurel Lake to London meant the city had the necessary water for factories, according to a respondent from the Laurel County Historical Society. In 1960, Congress authorized construction of a dam on the Laurel River. The U.S. Army Corps of Engineers built the high Laurel River Dam between 1964 and 1974, and hydropower production began in 1977, resulting in safe drinking water, recreational opportunities, and low-cost hydroelectric power which ultimately helped crowd out coal and coal-powered electricity (Laurel County 2020).

The county's location and infrastructure have contributed to a relatively diverse economy. Many durable and nondurable manufacturing plants operate in London, KY, such as Aisin—a Japanese producer of automobile components and systems—Bimbo Bakeries USA, Flowers Foods, and others. In 2015, commuters from other counties represented about 55 percent of the county's workforce, and the county hosts seven industrial parks.

The county has also benefited from tourism-driven growth, notably as the birthplace of Kentucky Fried Chicken ((Colonel) Harland Sanders once lived in Laurel County). The county takes pride in its "annual world chicken festival", which is a tourist draw. Daniel Boone National Forest also spans parts of Laurel County, offering tourism amenities.

The role of networks and collaboration appear to have facilitated Laurel County's turnaround. There is evidence of longstanding collaboration between the county and its county seat, London. In 1971, the London-Laurel County Industrial Development Authority was formed to "secure and develop industrial parks and provide new locations for companies like Laurel Grocery, Walmart Distribution Center, and Aisin Automotive Casting" (Sentinel Echo 2019). London's mayor Troy Rudder notes:

> "The county's growth is largely due to the cooperation of local leaders who work together to continuously improve the quality of life for residents...the biggest part in our success is that the city and the county [work] closely together. You don't have that in most cities and counties. We've built such a close relationship between the city and county and that has helped us bring businesses here and improve the lives of everyone who lives and works here." (Johnson 2020)

Overall, Laurel County's economic transition and resilience appears to have been driven by its location and infrastructure capacity. The presence of an interstate highway likely facilitated greater industrial development by reducing transportation costs and increasing access to Laurel Country by nearby commuters. This was likely aided by effective collaboration between city and county government officials to leverage economic development opportunities.

Sequatchie County, Tennessee

Sequatchie County, Tennessee—the fourth, and final, Appalachian successful case-study—transitioned from coal mining largely in the 1980s. Sequatchie County's very small population of 6,331 in 1970 more than doubled by 2018, reaching 14,730. During the same period, mean household income rose from $42,550 to $64,711 (constant $2018), and the household poverty rate declined from 25 percent to 14 percent. As of 2017, its major sectors of employment were manufacturing (15.7 percent), retail trade (12.6 percent), and healthcare and social assistance (11.6 percent) (Data USA 2020).

Location played a key role in Sequatchie County's economic development. Part of the Chattanooga, Tennessee Metropolitan Statistical Area since 1973, the county's proximity undoubtedly contributed to its growth. Two major highways, U.S. Route-127 and Tennessee State Route-111, intersect in Dunlap, the county seat. For our case-study work, we contacted Southeast Tennessee Development District Director Beth Jones, who has 38 years of experience working in the county. She characterized Sequatchie County's transition from coal employment as follows:

> "Sequatchie County's success in transitioning away from coal has to do with its close proximity to Chattanooga and the construction of a major Appalachian Development Highway System (ADHS) Corridor, U.S. Highway-111 (known as Corridor J), which constructed a major divided two-lane highway from the north end of Hamilton County (Chattanooga), providing easy and quick access across the mountain into the Sequatchie Valley. Sequatchie County adopted a strategy of becoming a bedroom community to Chattanooga, offering very cost-effective real estate to retirees, workers, and others on incredible sites with vistas and views that are breathtaking. They worked with private developers to purchase mountain-top properties formerly owned by coal mine and timber companies to develop into residential properties. Both the city and county worked together to focus on providing critical infrastructure such as water, sewer, and roads to these sites; and as such folks have continued to buy and develop residential properties, retail has followed the growth; and the commute from Chattanooga to Sequatchie County takes no more than 30 minutes. I live on the north end of Hamilton County and can be to Dunlap as quick as I can be in downtown Chattanooga. They have worked diligently to keep the county beautiful and scenic – it provides a quaint, small town life with amenities very close to a mid-sized urban area. Sequatchie County has continued to be our fastest growing county for the past two census counts due to the influx of residents. The city and county have several industries, but primarily the focus has been on quality of life!"

The county's location provides recreational and scenic opportunities. It is part of the Cumberland Plateau, sitting more than 1000 feet above the Tennessee River Valley (Sequatchie County TN 2020).

Sequatchie County is home to Chattanooga State Technical Community College, providing a local source of workforce development.

Overall, Sequatchie County's path of successful economic transition was facilitated by its proximity to Chattanooga, enabling county residents to access a much larger and diverse job market.

Ouray County, Colorado

Our final case study considers the non-Appalachian Ouray County, Colorado, which transitioned from silver and gold mining employment, and is relatively prosperous today. We include Ouray County as an example of a hard-rock mining experience with similar characteristics to coal mining, but being in the Western United States, it has a different set of structural and cultural characteristics than Appalachia.

Ouray County's transition away from mining occurred from 1970 to 1980. Ouray County's 1950 population of 2,103 fell to 1,537 in 1970. Yet, by 2018, its population had tripled to 4,722. The 1970 mean household income of $49,029 increased to $87,907 in 2018 (constant $2018), and household poverty rates fell from 11 percent in 1970 to 7 percent in 2018. The main sectors of employment in 2017 were retail trade (22 percent), accommodation and food service (21 percent), and professional, scientific and technical services (12.6 percent) (Data USA 2020).

Natural amenities have played a big role in Ouray County. Ouray County has a rugged mountain topography and many national/state parks and trails. The county hosts the largest ice climbing event in North America. Additional tourism industries include mountain biking, hiking, trail running, and off-roading in four-wheel drive expeditions (Ouray County, Colorado 2020). The towns of Ridgway and Ouray in Ouray County have been the locations for numerous films, including True Grit and How the West Was Won. According to the Western Mining History Society:

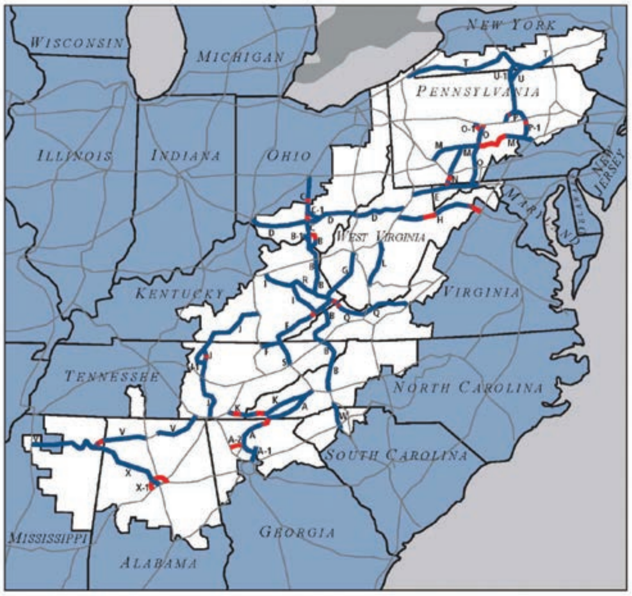
> "The closure of [mines in the early 1990s] spelled the end of Ouray's mining economy, but fortunately tourism become the major industry that continued to support the town into the 2000s. Today, Ouray is known as 'The Switzerland of America' and is one of Colorado's most popular tourist destinations. Many of Ouray's remaining historic buildings were built during the 1880s and 1890s. Ouray, Colorado is one of the West's best preserved mining towns from the 1800s. It also happens to be one of the most spectacularly beautiful destinations anywhere in America." (Ouray, Colorado 2020)

An important aspect of Ouray's tourism success was the early development of highways through its surrounding mountains. For example, the stretch of U.S. Highway-550 from Ouray to Silverton is known as the "Million Dollar Highway". The highway began as the Otto Mears toll road built in 1883 to link Ouray with the Red Mountain Mining District (Ouray, Colorado 2020). U.S.550 was part of the original 1926 federal highway system, and today the entire route is part of the San Juan Skyway Scenic Byway (Ouray County, Colorado 2020).

Ouray County's economic resilience appears to stem from its location, natural amenities and accessibility that make it a desirable tourist destination. The presence of a federal highway likely eased its transition to a tourism-based economy. Similar to the four ARC case studies, Ouray County shows that it is not necessary to have a large population in order to thrive after transitioning from reliance on a mining economy.

Figure 6.1

Map of Planned Appalachian Development Highway System in 2017



ADHS Miles Open to Traffic
ADHS Miles Not Open to Traffic
Interstate Highway System

Source: Appalachian Regional Commission, Map of the Appalachian Development Highway System as of February 25, 2018, https://www.arc.gov/adhs

Regional Economic Benefits of the Appalachian Development Highway System

The Appalachian Development Highway System (ADHS) has been a significant source of economic benefit to counties across the Appalachia region. The first highway system authorized by Congress for the express purpose of stimulating ARC economic development, the ADHS is a network of 31 distinct highway corridors totaling 3,090 miles that connects the ARC region with the Interstate Highway System (Appalachian Regional Commission 2019; Cambridge Systems, Inc. 2008). The corridors developed by the ADHS consist of a mixture of state, U.S., and interstate routes. As of September 2019, the ADHS is 85 percent complete, with another 5 percent open to traffic but planned enhancements not completed. Only 340 miles are unconstructed, though final completion dates are uncertain (ARC 2020). The purpose of the ADHS is to generate economic development in isolated areas and, by integrating the Appalachian region to the national transportation system, provide access to regional, national, and global markets.

The ADHS plan has slightly expanded over time. Figure 6.1 shows the system as it exists and is envisioned today. As of 2016, ARC has received over $34 billion in federal expenditures, with the majority going towards funding the construction of ADHS corridors. Congress appropriated $100 million in FY 2020 for ongoing ADHS construction (ARC 2020).

Since the beginning of ADHS's construction in 1965, it has led to improvements in terms of travel efficiency and direct and indirect economic impacts. Travel efficiency benefits have been immense, largely in the form of travel time and reliability. In their analysis of travel time saved, Economic Development Research

Group, Inc. estimates that "the ADHS now saves 231 million hours per year of travel each year, representing 632,000 hours per day, compared to what would have been without the ADHS. In addition to the hours of time saved by increased travel speeds and shorter routes on the ADHS, it is estimated that 129 million hours of 'reliability time' are saved annually, representing another 360,000 hours saved daily" (Economic Development Research Group, Inc. 2017, p. 5).

Besides saving travel costs, the ADHS has substantially helped Appalachian communities access goods and labor markets. The role of transport networks in facilitating the movement of goods and people is widely recognized as a key contributor to economic development and growth. The ADHS has promoted labor force accessibility in areas remote from major population centers, as well as in economically distressed counties (Economic Development Research Group, Inc. 2017). Investments in the ADHS have enabled the ARC region to attract businesses that spur economic growth; added business sales are estimated at over $24 billion annually, and added gross regional product is an estimated $11 billion per year ($2015) as a result of the ADHS (Economic Development Research Group, Inc. 2017). Not all counties benefited equally from the ADHS, which suggests that connectivity infrastructure addresses only part of the underlying challenges facing the Appalachia region.

The ADHS corridors have benefitted our case-study communities. Among our four Appalachian communities, three counties—Athens, OH; Laurel, KY; and Sequatchie, TN—are located on sections of an ADHS corridor. Athens, OH is connected to the ADHS through corridor D, while both Laurel, KY and Sequatchie County, TN are connected to the ADHS through corridor J. Although the ADHS does not intersect with Noble County, OH, it benefits from being crossed by U.S. Interstate 77.

- **Athens County has benefited from its proximity to Corridor D** (U.S. Highway 50), the major east-west route in southern Ohio (Appendix F, Figure 1). While already linked to Columbus, OH through U.S. Highway 33, the introduction of Corridor D facilitated shorter travel times to other key metropolitan areas such as Cincinnati, OH and Parkersburg, WV.[60]

- **Laurel County has benefited from Corridor J,** which intersects the county and whose northern terminus is Interstate 75 near London, KY, the county seat (Appendix F Figure 2). This is noteworthy because Interstate 75 is a critical transport route for U.S. manufacturing supply chains, especially for the auto industry. Completed in 1984, Corridor J runs through Kentucky counties Laurel, Pulaski, Wayne, Clinton, and Cumberland. It is estimated to have generated 3,785 additional jobs, $140 million in additional income, and a 5% drop in annual vehicle-miles-traveled, and a 29% cut in drive time (Econ Works 2020; Wilber Smith Associates 1998).

- **Sequatchie County is located near the Corridor J terminus in Chattanooga** (see Appendix F Figure 3). The section of Corridor J between Dunlap (Sequatchie's county seat) and US 27, built between 1988 and 1994 (Tennessee State Route 111, 2020), provides an additional commuting route into Chattanooga, whose metropolitan area had a 2019 population of 563,000 (compared to 183,000 within Chattanooga's city limits; U.S. Census Bureau).

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[60] According to some of the region's residents, "With the highway in place, people in Appalachian Ohio can work the next county over, or drive to Athens or Cincinnati for work or recreation – time-consuming or impossible before the highway was built" (Fugleberg 2016).

Conclusions and Policy Implications

The aim of this study is (a) to identify Appalachian counties that have been relatively successful at transitioning from coal-based economies, and (b) to identify factors that promoted this transition. The rise and decline of U.S. coal production over the last century had the effect of building mining-dependent economies across the remote counties of Appalachia through coal-based employment, and then exposing these communities to severe negative shocks as demand for coal dried up. Many of these relatively small and remote communities were already lagging in terms of socio-economic development; the sharp reduction in coal demand over the past several decades created further dislocation that undermined their economic sustainability. The magnitude of the impact across Appalachian counties varies, as does the degree of economic resilience and capacity to transition to alternative industries. Some counties transitioned early, while others delayed the difficult and costly adjustment needed to diversify their local economies.

To understand these differences, we draw on evidence from the traditional economics literature, as well as broader research disciplines related to economic geography, demography, sociology, and community capital to identify the main variables associated with economic transition and local economic development most relevant to the Appalachian experience. We use these variables to develop a measurement strategy to compare transition performance across the 420 ARC counties and select the best performers.

Our quantitative analysis identifies four Appalachian counties that have been most successful in growing their communities while eliminating dependence on coal jobs: *Athens and Noble Counties in Ohio; Laurel County, Kentucky; and Sequatchie County in Tennessee.* We complement our quantitative findings with qualitative case-study research on each "successful" Appalachian county to try to understand the factors associated with successful transition.

The following main conclusions emerge from our combined quantitative and qualitative analysis:

- **Very few counties manage a positive transition.** Out of 222 ARC counties with a high level of coal dependence at some point after 1950, only four counties managed to transition out of coal and remain economically viable with sustained population growth. This result is surprising in light of global trends in coal's declining competitiveness, especially Appalachian coal, and sharply lower market demand.
- **In terms of economic well-being, the four counties' level of success is modest.** While the four counties have grown in population and diversified production, and most have experienced significant poverty reduction, average household incomes are relatively low and poverty rates exceed both the national and ARC averages. Median household income in the four successful coal-transition counties is below the top-10 fastest growing mining counties, as well as the 10 slowest growing mining counties. Moreover, the highest-performing and poorest-performing mining-intensive counties had lower initial poverty rates than the four successful counties, and still have lower poverty rates today.
- **Severe structural impediments across Appalachia constrain growth.** Being small and remote, most ARC counties have limited access to labor markets that offer more and diverse job opportunities. ARC counties have low levels of physical capital—especially infrastructure—and human capital, with lower educational attainment and lower quality education and health services. High transport costs, both for bringing in intermediate and final goods and for exporting outputs, reduce firms' competitiveness and raise the cost of living for residents.
- **Non-structural impediments reinforce poor economic outcomes and reduce local economic resilience.** Historically coal-dependent communities exhibit less economic diversification; more uniform, low-skill job profiles; and local labor market wage distortions (driven by high-paying mining jobs). The modest share of manufacturing activity—which tends to serve larger, non-local markets and raises average productivity and wages compared

to resource or service-based sectors—also increases the economy's vulnerability to coal price shocks, thereby locking-in path-dependence. The patterns of boom and bust cycles and low levels of entrepreneurship reflect limited flexibility to adapt to changing market realities.

- **Institutional capacity and social capital matter.** Local government capacity and social capital are generally low across the ARC region compared to national averages, as measured by common proxy measures. This may explain why ARC counties were lagging even prior to coal transition. The case studies highlight examples where local government capacity to design, finance, and implement economic development initiatives and attract external financing—especially in collaboration with local civil society agencies and regional government authorities—seems to help sustain the transition impetus.

- **Transition paths in our four "successful" Appalachian counties reflect idiosyncratic, unique features that drove their success:**

  - **Athens County's economic development has centered around its large public Ohio University,** which created high-skilled teaching, administrative, and health services jobs and stimulated local businesses to provide goods and services to the large student population. The university has also fostered innovative graduate or affiliated start-ups, generated social capital by coalescing community members' interests around enhancing the university community, and has raised institutional capacity within the county.

  - **Noble County, despite its small population, was able to attract a large public investment to build a state prison, which provides ongoing economic stimulus.** It also benefited from good highway connections.

  - **Laurel County's relative success at diversifying from coal is largely due to major infrastructure improvements.** These included construction of two highways, the regional London-Corbin Airport, a major dam, and investments in piped water and hydroelectric power. These investments connected the county to key manufacturing supply chains, and helped it exploit some unique tourism opportunities.

  - **Sequatchie County found alternative post-coal economic stimulus through its proximity to Chattanooga, TN and investments in highways** to access this large metropolitan market offering diverse job opportunities.

Are there any common features or lessons that can help policymakers and local community leaders promote transition toward a sustainable post-coal economy? We do not offer specific policy recommendations, because this would require a comprehensive assessment of county, regional, state, and federal policies in the ARC region and how these have affected outcomes. Detailed research on the incentive framework that steers producers' and workers' decisions, and the fiscal stance and public investment decisions by particular counties or states, is beyond the scope of our research. Nor do we examine regional and national coal-specific policies and incentives relevant to the local policy context.

Our analysis points to some broad approaches policy makers should consider to address common economic development impediments in Appalachia:

- **Enhance connectivity:** For remote communities, connectivity to larger markets is essential for growth, although infrastructure investments alone are not enough to guarantee successful community transition from coal dependence. Connectivity is key to achieve scale economies and competitive margins for locally produced goods and services, as well as for matching excess labor supply with jobs in nearby markets. Even when remoteness represents an asset by virtue of natural amenities, deriving economic value from these amenities—such as through recreational services and tourism—requires non-residents to be able to access these communities. Infrastructure that supports this connectivity—whether roads or internet digital connectivity—is necessary but not sufficient to support diversified economic development. This is illustrated by the fact that the ARC region is filled with distressed counties that also received significant government investments, beginning with the Tennessee Valley Authority (TVA) in the 1930s, and later through ARC and POWER programs and widespread ADHS road investments throughout the region.

- **Invest in human capital:** Enhancing human capital through investments in education and health services quality and/or access will improve residents' well-being, even in the absence of a market return on their improved human capital. Similar to physical infrastructure, increasing human capital makes workers more productive and allows them to compete for better, higher-skilled jobs and generate more added value. But in the absence of employer labor demand, human capital investments will generate negligible returns, and may raise job seekers' expectations for skilled jobs that are not available locally. Lessons from successful investments in education and training require aligning the curricula with identified private sector needs or focusing on developing entrepreneurial capacity for new business start-up.

- **Seek economic diversification to ease "boom and bust" cycles:** The long-term economic health of coal-dependent communities requires that government authorities and civil society make concerted efforts to facilitate new economic activities and move beyond the coal "boom-bust" cycle. Resource-dependent economies are subject to volatility due to market fluctuations in the value, and therefore profitability, of their resource extraction and production activities. We illustrated how volatile coal "boom-bust" cycles in Appalachia affected county-level mining employment. Dependence on commodity-based sectors is associated with long-term economic and social costs, such as reduced economic activity and entrepreneurship, slower average economic growth, and weak institutional capacity to meet local social needs (Betz et al. 2015, Billings and Blee 2000, Duncan 2014). The promise of a future new "boom" cycle delays difficult decisions, especially those that entail short-term costs, such as job losses. Attracting investments in new firms that serve a local or regional market niche, or that reach more distant markets seeking their products or services—which in turn depend on local inputs—can stimulate local job creation and value addition.

- **Build local institutional capacity:** Diversifying sectors of economic activity requires effective local institutional capacity to develop an enabling business environment. Governments are responsible for providing public goods consistent with economic development, and they must design and enforce the right mix of rules and regulations. Governments can also play an active role in stimulating private sector activity, such as through investment incentives, public-private partnerships (PPP), local-content procurement thresholds, and strategic planning to promote priority sectors, to name a few options. Coordinating with local stakeholders and regional agencies and collaborating with neighboring communities or state authorities to design complementary approaches can maximize economic impacts and potentially leverage more financial and/or institutional support. This approach appears to have been effective in successful transition counties, which are part of ARC-established, multi-county local economic development areas.

- **Coordinate economic development strategies:** Ultimately, counties that are economically constrained need a coordinated set of economic development strategies and approaches to (a) foster larger economic agglomeration and/or linkages to larger regional/national/global markets, and (b) exploit natural amenities in a sustainable manner that can attract demand for local services. Some communities may not have the minimum endowments to remain, or become, economically viable in the absence of coal. Policymakers at the state and national levels will need to weigh the fiscal cost of propping up very small communities against the opportunity cost of not investing in communities with greater economic potential. This will require a hard look at communities' long-term sustainability, and consideration of alternative approaches, such as facilitating out-migration through mobility grants or other incentives.

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APPENDIX A

Targeted Literature Review and Findings

In this Appendix, we present the results from the targeted literature review. We explain the methodology of selecting and classifying the studies that are used to inform section 2 of this report, which addresses the factors analysts have identified as barriers or facilitators to improved community well-being in light of resource and other transitions.

Methodology: Selection of Studies

We used two databases to procure the necessary literature. The first database was "Web of Knowledge." Within this database, we key-termed searched for the following: "just transition"; "transition from coal"; "mono-industry economies"; "military base closures"; "rural economic resiliency"; and "social impacts of resource extraction." To develop the pool of literature for this report, we constrained the surveyed literature to those articles written between 1992 to the present and focusing on communities or impacts within the United States. Results were further constrained to the following social science disciplines: economics, geography, public administration, sociology, and general social sciences. Next, search results were ordered by Times Cited to ensure that the most referenced and consequential works were reviewed. We then proceeded to review additional citations from the articles we reviewed. The second database was the Appalachian Regional Commission's (ARC) digital archive of reports. Within the research reports archive, we searched for using the before mentioned key-terms. We then selected reports that focused on assessing previous policies or programs aimed at assisting Appalachian communities through the transition away from coal.

The resulting literature summarized in this report, therefore, mainly comprises published refereed articles from academic journals as well as reports from governmental and non-governmental agencies. Our findings are based on 37 articles we found most relevant to the research questions this report aims to address. However, we also reviewed approximately 30 additional articles that we deemed not to include for several key reasons. First, because our focus is on the just-transition in the United States and because we aim to draw parsimonious conclusions for researchers and policy-makers, we excluded literature where that nation was not the centerpiece. Thus, we excluded articles on the just-transition in European Union countries and Australia as well as articles on the impacts of coal mining and resource extraction in developing countries within the Global South. Second, we excluded articles that were reviews of the literature, specifically if those reviews did not focus on the social impacts of transitions from coal or coal employment, but rather on the available data and statistical modeling techniques available for assessing the effects of a transition. Third, we excluded review articles that were mainly theoretical or conceptual. These pieces were more abstract discussions about what could or should be done to assist in the just transition, rather than providing concrete information about what is being done currently. Finally, we excluded articles that focused on the successful endurance and resilience of industries within communities rather than their decline and communities' responses to such declines. As a result, the included literature summarized in this report represent the major research on the topic, but due to the selection criteria and the inherent limitations of research reviews, they are not exhaustive of past work.

Classification of Studies

In Appendix A Table 1 we classify these studies by four general criteria: 1) the methodology employed; 2) the thematic focus of the study; 3) the impact or outcome variable(s) examined; and 4) what factors matter in terms of the opportunities for community revitalization and the barriers to community improvement.

In classifying the studies by methodology, we found several major types of research designs. The most commonly employed research design were quantitative empirical analyses. These studies mainly were regional impact assessments typically involving regional econometric and/or input-output statistical models using either secondary or primary survey data to assess the community impact of industries' decline or change. The unit of analysis in these studies is the community and most of these studies are concerned with the impacts of industry change across counties. Second, the studies reviewed included qualitative empirical analyses research designs. These studies included case-studies focused on single or a small number of communities or projects, and/or interviews with key community informants, and/or focus groups among community residents. Next, additional studies reviewed included policy evaluations which aimed to assess policies already implemented in attempts to revitalize communities experiencing losses in coal employment. The remaining studies included systematic literature reviews of past studies to assess the current state of scholarly knowledge about the impacts of various industries on community well-being. Finally, studies are classified by scale of their unit of analysis, and include: cities; counties; states; and regions.

To further classify the studies reviewed, we included three major categories for the thematic focus of studies. First are studies focused on the impact of employment in various industries (e.g., coal mining, oil and gas mining) on community well-being. The next classification of studies comprises event-based studies on the impact of temporal changes in the global or local economy (e.g., various shocks and boom and bust cycles) on community well-being. The last major category of studies includes those focused on policy implementation – both planning for future implementation and evaluating policies previously applied.

The third class of studies is based on the impact or outcome variable(s) examined by the reviewed literature. The most common outcomes explored were related to communities' socioeconomic well-being and included indicators such as poverty rates, employment rates, median household income, etc. A second type of impacts were those on individuals' attitudes and perceptions, such as acceptance of coal employment decline, perceptions of just transitions, and views of community change in light of shocks. The final type of outcomes explored were the extent to which policy interventions and implementations accomplished their intended goals.

The final class considers the factors that mattered to the outcome variable(s) and include either opportunities or barriers. Opportunities include those factors found to have positive impacts and/or improve community well-being; barriers include those factors found to have negative impacts and/or impede community well-being. The factors that mattered, as both opportunities and barriers, were further parceled into categories of main factors (e.g., the focus of the study) and other factors (e.g., geographical location, local economic structure).

Overview of Table 1 Sections

- **Citation**
  - ***Abbreviated Citation:*** First Author, Date, Title
- **Methodology**
  - ***Research Design Format:*** Quantitative empirical analysis (primary survey data or secondary data); qualitative empirical analysis (focus groups, case-studies, interviews); policy evaluations; systematic literature reviews.
  - ***Scale of Study:*** City; county; state; region
- **Focus of Studies**
  - ***Employment by Industries:*** Coal mining; oil and gas mining; general mining; restoration economy; manufacturing
  - ***Event:*** Temporal changes in global/local economy (e.g., economic shocks; boom and bust cycles); military base closures; just transition
  - ***Policy:*** Assessing policy intervention(s); proposed policies expected effects
- **Community Impact Indicators**
  - ***Socio-Economic Well-Being:*** Poverty; employment; income; social capital; population size/density; educational attainment; crime rates; affordable/safe housing
  - ***Individuals' Attitudes:*** Acceptance of coal employment's decline; perceptions of transition away from coal; perceptions of who/what is responsible for coal's long-term decline; and perceptions of who is responsible for paying for policies to assist in the transition away from coal.
  - ***Policy Evaluations:*** Extent to which policy/programs accomplished intended goals
- **What Mattered?**
  - ***Opportunities:*** Positive impacts and/or factors that improve community well-being
  - ***Barriers:*** Negative impacts and/or factors that impede community wellbeing
    - ***Main Factor:*** See focus of studies.
    - ***Other Factors:***
      - ***Geographical Location:*** Rural-urban location; proximity from metropolitan areas
      - ***Local Economic Structure:*** Local industrial composition; unionization; entrepreneurialism rates
      - ***Demographic Composition:*** Age composition; educational attainment; racial/ethnic composition; population size/density;
      - ***Institutional Factors:*** Governmental or non-governmental amenities/services/policies; government capacity (fiscal and/or administrative); communities' social capital; intergovernmental collaboration/coordination
      - ***Other:*** Temporal changes in global/local economy (e.g., boom and bust cycles, economic restructuring

Appendix A Table 1:

Targeted Literature Review, Table of Findings

Citation	Appalachian Citizens' Law Center et al. 2019. "A New Horizon: Innovative Reclamation for a Just Transition."
Methodology	20 case-study communities in Virginia, West Virginia, Kentucky, and Ohio **Policy evaluation**
Focus of Studies	**Policy:** assessing the impacts of Abandoned Mine Lands recovery projects
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** development of economic opportunities in three different sectors: 1. Recreation and ecotourism 2. Solid waste, recycling and sustainable materials management 3. Technology (Renewable energy)
What Mattered?	**Barriers** • A glut of vacant, condemned properties (brownfields) that hamper redevelopment of the properties for new economic development opportunities and growth. • Lack of private investment capital and return on investment potential – less certain returns hamper development in these areas. • Unknown extent of contamination and cleanup costs are potentially prohibitive without major assistance from public or philanthropic funding sources. • Many low-income communities, like coalfield municipalities, suffer from a lack of municipal and civil society capacity to lead extensive multi-year, multi-stakeholder redevelopment processes. • The lack of legal and development expertise hinders planning and momentum at the local level and requires obtaining outside support. **Opportunities** • Projects start with robust and locally-grounded planning process for project concept development. • Providing essential support to local stakeholders to plan for the regions' economic futures. • Need for restoration economy to accelerate the adoption of innovative approaches to land restoration that contribute meaningfully to the regions' economic rebirth.
Citation	BenDor, Todd K. et al. 2015. "Defining and Evaluating the Ecological Restoration Economy: Defining and Evaluating the Restoration Economy."
Methodology	14 case-studies of restoration projects at national, state, and county levels **Systematic literature review**
Focus of Studies	**Employment by industry:** restoration economy
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** employment multiplier effects of the restoration economy.
What Mattered?	**Opportunities** • Restoration investments appear to have particularly localized benefits which can be attributed to the tendency of projects to employ local labor and materials. • Studies show a range of 6.8-39.7 jobs per $1 Million invested for the restoration economy • Studies show range of employment multipliers of 1.97-3.8 for the restoration economy

Citation	Besser, Terry L. et al. 2008. "The Impact of Economic Shocks on Quality of Life and Social Capital in Small Towns."
Methodology	99 small towns in Iowa Longitudinal survey data gathered from residents (1994 & 2004) and telephone interviews with key informants (2004) **Quantitative empirical analysis of primary data & qualitative empirical analysis of primary data**
Focus of Studies	**Event:** community economic shocks (e.g., loss of major employer, opening of new prison, boom and bust from energy development, natural disasters)
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** Quality of Life (QoL) • Factor scale composed of three items measuring residents' overall satisfaction with government services, non-governmental services, and the community in general. Social Capital • Perceptions of Within-Community Social Capital • Perceptions of Between-Communities Social Capital
What Mattered?	**Opportunities** • Gaining employment (+) * on QoL & both forms of between group social capital • Non-governmental amenities (+) ** on QoL & Structural between-group social capital • Net sum of community shocks are (+) * on QoL, subjective between-group social capital, & structural within-group social capital **Barriers** • Losing employment (-) * on subjective within-group social capital *The significance of the net sum of shock significance suggests that the cumulative strength and degree of the shock are more important than the kind of shock in predicting changes in QoL and social capital in a community.*

Citation	Betz, Michael et al. 2015. "Coal mining, economic development, and the natural resource curse."
Methodology	Continental U.S. counties & separate counties within the Appalachian Regional Commission (ARC) borders for two time periods: 1990-2000 and 2000-2010. **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** total county coal mining employment share and the impact on community well-being indicators
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** percent changes for the decadal models (1990-2000 and 2000-2010): 1. Per capita income 2. Wage and salary income 3. Median household income 4. Rental and investment income 5. Population 6. Accommodation employment 7. Retail employment 8. Level-measure of poverty rate 9. Employment/population ratio 10. Disability/employment ratio 11. Proprietors' share of total employment.
What Mattered?	**Opportunities** • Coal employment is generally associated with more positive (or less negative) effects in the post-2000 boom period relative to 1990s; these results hold across US and ARC counties • Coal mining appears to have benefits to lower and middle-income households for the U.S. as a whole • 1960 poverty rates were (+) * on change in socio-economic well-being **Barriers** • ARC counties tended to fare worse on economic indicators relative to other U.S. counties • Coal employment appears to not have same benefits to lower and middle-income households in ARC counties • Coal employment (-) * on changes in population and measures of entrepreneurship as reflected by self-employment measures; these relationships are particularly strong in ARC counties • Oil and gas employment generally had negative impacts on socioeconomic wellbeing, particularly during the 90-00 period.

Citation	Black, Dan, et al. 2005. "The Economic Impact of the Coal Boom and Bust."
Methodology	Counties in Kentucky, Ohio, Pennsylvania, and West Virginia Boom-bust cycle in 1970-1980s: Boom, 1970-7 Peak, 1978-82 Bust, 1983-9 **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry & event:** coal mining, employment, and earnings per mining worker and the impact on community well-being across boom-bust cycles
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Employment Multipliers: jobs created in traded or local sector per job created in mining sector 2. Wage growth by sector, 1970-80 & 1980-90 • Mining • Non-Mining • Construction • Retail Trade • Services • Manufacturing 3. Population Growth by Gender, 1970-80 & 1980-90 4. Change in Poverty, 1970-80 & 1980-90 Testing is for differences in average annual changes in the logarithm of employment, earnings, and earnings per worker for the non-mining sector between treatment and non-treatment counties. Treatment counties are those that produce at least 10% of their total earnings from the coal industry in 1969.
What Mattered?	**Opportunities:** • Coal boom spurred economic growth in the non-mining sectors of coal dependent counties. • Employment grew during the boom in construction and service sectors • Coal boom and bust did generate modest employment spillover into local sectors. • Coal boom decreases number of families in poverty. **Barriers:** • Employment declined during the bust for all three non-mining local sectors (construction, retail, and services). • Earnings per worker also decrease in all three local sectors during the bust • The multiplier effect of the bust is almost twice the size of the multiplier effect of the boom (for every 10 jobs lost in the coal sector, 3.5 jobs were estimated to be lost in construction, retail, and service sectors) • Bust produces wage declines in all sectors. • Bust produces population declines for both men and women ages 10-39. • Bust produces increases in the number of families in poverty.

Citation	Carley, Sanya, et al. 2018. "Adaptation, Culture, and the Energy Transition in American Coal Country."
Methodology	Focus-groups with individuals that reside or work within the range of Appalachia identified (25 individuals; conducted in 2 WV cities) + 23 interviews with experts **Qualitative empirical analysis**
Focus of Studies	**Event:** coal mining communities' perceptions and acceptance of transition away from coal.
Community Impact or Outcome Variable(s)	**Individuals' attitudes:** residents of coal communities' acceptance of – 1. The energy transition 2. The implications of the transition for their personal circumstances 3. How they fared as the transition has evolved in their own community
What Mattered?	**Opportunities:** • Respondents perceived that new professional opportunities encouraged acceptance of the transition • Perception that emphasis on training or community college programs to prepare community members for transition **Barriers:** • Perceived that lower levels of education across coal miners and their families make them more susceptible to shock and limits their potential adaptability • Community cultural identity of mining • Lack of alternative economic opportunities within coal communities • Promise of return to coal jobs (e.g., Trump administration_ is damaging to community and individuals' efforts to adapt and accept changes.

Citation	Chamberlin, Molly et al. 2019. "Success Factors, Challenges, and Early Impacts of the POWER Initiative: An Implementation Evaluation."
Methodology	Evaluation and report on the qualitative impact of investments made to date with POWER (Partnerships for Opportunity and Workforce and Economic Revitalization) Initiative Sample of 88 grantees were selected for document review and experiences with implementation. **Policy evaluation**
Focus of Studies	**Policy:** POWER initiative – an evaluation of 88 projects and whether they met their shared objectives of projects.
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Economic Diversification 2. Job Creation 3. Capital Investment 4. Workforce Development 5. Reemployment
What Mattered?	**Opportunities:** • Success factors related to target population recruitment and engagement of community residents: • Strategic recruitment; Use of multiple types of media; Tailoring programming; Demonstrating progress to participants • Success factors of projects related to organizational capacity: • Internal resources; Organizational experience and reputation; Promoting a creative and nimble organizational culture • Success factors related to partnerships and collaborations: • Building of community self-determination; Building a pipeline of future leaders; Increasing grantee presence and connection with communities **Barriers:** • Common challenges for the recruitment of residents/workers as well as retention and continued engagement in programs included: • Participant reluctance; Competition among organizations; Access to funding and capital • Common challenges related to organizational capacity included: • Project or time management; Adequate staffing; Financial management; Grants management • Common challenges related to partnerships and collaborations: Limited pool of community resources; Social and environmental barriers; Community infrastructure

Citation	Cook, Ak. 1995. "Increasing Poverty in Timber-Dependent Areas in Western Washington."
Methodology	Counties in Western Washington: 8 timber-dependent non-metropolitan counties 4 nonmetropolitan counties that are less timber-dependent 7 metropolitan counties **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** timber-dependent employment (forestry/fisheries and furniture, lumber and wood products).
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** poverty rates
What Mattered?	**Barriers:** • Percent change in labor force participation by both men and women were lower in timber-dependent counties • Wage and salary incomes were lower in timber dependent counties • Greater number of female-headed households in timber-dependent counties → higher poverty rates.
Citation	Cowan, Tadlock. 2012. Military Base Closures: Socioeconomic Impacts.
Methodology	Communities/localities with military bases **Systematic literature review**
Focus of Studies	**Event:** military base closures (BRAC)
Community Impact or Outcome Variable(s)	Socio-economic well-being: employment multipliers & income multipliers **Input-Output analyses**
What Mattered?	**Barriers:** • Rural location – harder to recover from loss of base • Loss of population potentially leading to loss of local government revenues Opportunities • Employment multipliers were less than one ~ losses were associated with military transfers out of the area • Per capita income was little affected by the closures • Widespread community commitment to a sound plan for base reuse has been shown to be crucial to positioning communities to life without a military base.

Citation	Daniels, S.E., et al. 2000. "Reemployment Programs for Dislocated Timber Workers: Lessons from Oregon."
Methodology	Evaluation of policy implemented in 2 counties in Western Oregon through interviews with displaced timber workers 1. Linn County – 15% employment tied to timber; six communities classified as timber dependent 2. Benton County – more diversified economy based on timber and wood products Assessment of 2 worker training programs **Qualitative empirical analysis & policy evaluation**
Focus of Studies	**Policy:** reemployment programs for Displaced Timber Workers
Community Impact or Outcome Variable(s)	Individuals' attitudes: Perceived Success of and Satisfaction with reemployment as the result of two programs: 1. State initiated career planning workshop – Choices and Options (C&O) – 2-week workshop *Designed and implemented by three agencies: local Job Training Partnership Act (JRPA) agency, community college, and employment department.* 2. Federal initiative – Jobs in the Woods (watershed restoration projects) – provided means to receive classroom and field work retraining in new occupation – ecosystem restoration – while they worked in the woods and earned a wage. Designed by State Community Economic Revitalization Team; implemented by steering committee composed of representatives from the state economic development agency, higher education, federal and state land management agencies, local JTPA agencies, and labor.
What Mattered?	**Opportunities** • Both programs produced modest, positive effects on the displaced workers' job satisfaction **Barriers** • Challenges to starting small business in nascent industry (ecosystem restoration)

Citation	Deaton, James B., et al. 2012. "An Empirical Examination of the Relationship between Mining Employment and Poverty in the Appalachian Region."
Methodology	399 Counties in Appalachia (ARC) **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** mining employment
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** poverty rate Using panel data decomposition models the effects of an increase in a sector's employment share to identify an immediate and lag effect.
What Mattered?	**Opportunities** • Immediate effect of increased mining employment is (-) * on poverty rates • Share white population (-) ** • Share high school graduates (-) ** **Barriers:** • Higher share of mining employment, at the expense of manufacturing, agriculture, or service sectors, (+) * on long-term poverty rate • Share of dependent population (+) ** • Unemployment rate (+) **

Citation	Douglas, Stratford and Anne Walker. 2017. "Coal Mining and the Resource Curse in the Eastern United States."
Methodology	409 Appalachian Counties (1970-2010): Compare coal counties to coal-free counties **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** resource-sector dependence as measured by employment in coal mining
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** long-run (1970-2010) per capita personal income growth
What Mattered?	**Barriers:** • A one standard deviation increase in resource dependence is associated with 0.5-1 percentage point (-) in annual long-run growth rate of per capita personal income • A standard deviation in resource dependence is associated with a 0.2 percentage point (-) in annual short-run growth of per capita personal income • Disincentives to education explain about 15 percent of the apparent resource curse of resource-dependence **Opportunities** • Metropolitan counties had (+) ** on growth in per capita personal income
Citation	Freudenburg, William R., and Lisa J. Wilson. 2002. "Mining the Data: Analyzing the Economic Implications of Mining for Nonmetropolitan Regions."
Methodology	Meta-analysis of all quantitative studies on mining (301) comparing nonmetropolitan mining regions compared against other nonmetro regions and/or their own experiences over time. **Systematic literature review**
Focus of Studies	**Employment by industry:** mining and mining dependence
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Income 2. Poverty 3. Unemployment 4. Overall Findings
What Mattered?	**Barriers** • Mining has predominantly adverse for unemployment, poverty, and overall findings • Findings of favorable economic conditions in mining regions have become relatively rare since 1982, making up only about 20 percent of the available findings that come from 1983 and thereafter. Meanwhile, adverse findings make up nearly three times that number (57.3%) for the same era. **Opportunities** • Income has greater favorable outcomes among the reviewed studies (47.5%); while only 33.9% are adverse and 18.6% were neutral. • Mining in western region had more favorable outcomes (52.1%) than in South, Great Lakes, or Other regions

Citation	Graff, Michelle, et al. 2018. "Stakeholder Perceptions of the United States Energy Transition: Local-Level Dynamics and Community Responses to National Politics and Policy."
Methodology	Interviews and surveys with community energy stakeholders (individual sand organizations working on the energy transition – both non-profit, private, and public sector) on perceptions in three frontline communities: 1. Detroit, MI 2. St. Louis County, MO 3. Appalachia Coal Country (Counties in KY and WV) **Qualitative empirical analysis**
Focus of Studies	**Employment by industry:** sectors related to energy transition: 1. Automobiles 2. Coal company headquarters and coal railroad hub 3. Coal mining
Community Impact or Outcome Variable(s)	**Policy evaluations:** 1. Community Activities related to Transition 2. Actors and institutions across communities leading (or not) on energy policy issues
What Mattered?	**Opportunities:** • Solar farms, panels and policies offering new economic opportunities • Perception that "bottom-up" approaches are more successful than "bottom-down" efforts **Barriers** • **All localities:** · Lack of mobility of local residents · Necessity of moving for economic opportunities but lack of affordable housing and place attachment impeding ability to move • **Appalachia** · Job loss – layoffs and business closures in other local industries · Concern about wider adverse labor market effects – schools and retail closing due to families migrating out of communities · Vulnerable populations – low income and minority groups & individuals just entering the labor force (age 18-25); those in mid- to late-stage career (age 50+), and women. • **Detroit and St. Louis** · Concern about potential for increasing utility prices · Lack of understanding about the potential benefits and opportunities inherent in transition · Vulnerable populations – low income individuals and communities of color particularly vulnerable

Citation	Greenberg, Pierce. 2018. "Coal Waste, Socioeconomic Change, and Environmental Inequality in Appalachia: Implications for a Just Transition in Coal Country."
Methodology	Neighborhoods (Census tracts) in Central and North Central Appalachian Region between 1990-2000 **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** Coal waste impoundments (negative environmental externality of mining)
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** change in poverty rate from 1990-2000
What Mattered?	**Barriers** • Proximity to impoundments (+) * with poverty rate change • Higher levels of mining employment have (+) * poverty changes over time **Opportunities** • Past poverty rate (1990) was (-) * to poverty change over time.
Citation	Haggerty, Julia H., et al. 2018. "Planning for the Local Impacts of Coal Facility Closure: Emerging Strategies in the U.S. West."
Methodology	Characterization and assessment of strategies of local governments policies surrounding the closing of coal-fired plants in the U.S. West. **Systematic literature review**
Focus of Studies	**Employment by industry**: coal-fired power plants
Community Impact or Outcome Variable(s)	**Policy evaluations:** four key transition planning criteria for coal plant retirements 1. Importance of replacing and stabilizing revenue streams 2. The necessity to plan, fund, and execute complete environmental remediation 3. The risk of focusing on economic development strategies that are inappropriate to local context 4. The association of willingness to change and positive outlook with community resilience during transitions
What Mattered?	**Barriers** • Remoteness • Lack of alternative economic opportunities • Low education of populations • Uncertainty surrounding policies and government funding for rural services • Degraded environments associated with coal mining and coal burning can hamper long-term growth • Many communities do not have adequate health services, universities or training centers • Resistance to change – tend to blame closure on restrictive environmental regulations, while ignoring role of markets, particularly price competition with natural gas **Opportunities** • Promoting agro-tourism and outdoor recreation • Existing transmission infrastructure as competitive advantage for renewable development

Citation	Haggerty, Julia. 2014. "Long-Term Effects of Income Specialization in Oil and Gas Extraction: The U.S. West, 1980-2011."
Methodology	Counties within six major oil and gas producing states in the US West: Colorado, Montana, New Mexico, North Dakota, Utah and Wyoming between 1980-2011 **Quantitative empirical analysis from secondary data**
Focus of Studies	**Employment by industry & event:** oil and gas specialization
Community Impact or Outcome Variable(s)	**Socio-economic well-being for 1980-2011 (effect of duration of boom):** **1. Per capita income*** **2. Average earnings per job** **3. Total employment** **4. Total income** **5. Per capita investment income** **6. Unemployment rate** **7. Percent of adults with college education*** **8. Percent of individuals in poverty** **9. Percent of renter occupied units with gross rent >35% of household income** **10. Gini coefficient** **11. Violent and property crimes per 1000 people*** **only three found to be statistically associated with the duration of oil and gas development.*
What Mattered?	**Opportunities** • Shorter duration of boom associated with (+) * per capita income growth (relative to longer duration boom) **Barriers** • Per capita income (-) * over the period if county participated in 1980-82 boom • The longer a county has specialized in oil and gas, the higher the county's crime rates • Longer specialization in oil and gas associated with fewer adults with a college degree

Citation	Haggerty, Mark. 2019. "Communities at Risk from Closing Coal Plants."
Methodology	Report summarizing characteristics of communities most at risk from coal plant closures Technical report based on *Coal Transition Solutions Forum* which brought together 17 diverse participants to share their expertise in local and state government, academia, consulting and policy work. Policy evaluation
Focus of Studies	**Employment by industry:** coal plants
Community Impact or Outcome Variable(s)	**Policy evaluations:** vulnerabilities and barriers to transition

What Mattered?	**Barriers**
	• Isolation from major population centers and markets
	• Limited institutional and leadership capacity (e.g., little or no planning staff); lack capacity to apply for federal and state assistance.
	• Weak ties to state or regional actors, thereby limiting access to regional and state support for transition.
	• Fragmented ownership of plants and mines
	  · Owners will vary in response to different incentives depending upon their ownership structure and their customer base.
	• Workers and families are "stuck-in-place" due to mortgages or other factors.
	• Have older/aging workforce that are highly skilled, yet overly adapted.
	• Long-term dependence on coal-revenue
	  · Delays acceptance of transition
	• Lacks adequate fiscal autonomy – state restrictions on local budgeting authority.
	• Few funds or none for transition planning and implementation
	• Lack adequate information to assess fiscal risks and the limitations imposed by state and federal fiscal policies
	• Federal assistance is over-prescribed and poorly targeted – limiting local autonomy and flexibility to use funds to meet locally defined needs.
	Opportunities (Potential)
	• Reallocate coal revenue to transition needs and priorities
	  · Reform current tax policies that mandate that coal revenue be used for tax relief. Coal revenue would be used for transition purposes including permanent savings and long-term investments.
	• Broaden the tax base to replace coal revenue
	• Ensure resource taxes address transition needs and priorities
	• Fund effective federal grant and loan programs for coal communities
	• Secure one-time transition payments from facility owners
	• Increase local fiscal autonomy, including allowing for local savings authority

Citation	Haller, Melissa, et al. 2017. "The End of the Nuclear Era: Nuclear Decommissioning and Its Economic Impacts on U.S. Counties."
Methodology	County level study of 24 nuclear reactors that have undergone decommissioning from 1975-2014. **Quantitative empirical analysis of secondary data**
Focus of Studies	**Event:** nuclear decommissioning
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Employment 2. Income 3. Population **Method** • Difference-in-difference regression • Propensity score matching
What Mattered?	**Opportunities** • Decommissioning (+) * in employment and per capita income over time **Barrier** • Decommissioning has a non-significant effect (neither positive or negative) on population growth over time
Citation	Hooker, Mark A. and Michael M. Knetter. 2001. "Measuring the Economic Effects of Military Base Closures."
Methodology	57 counties with military bases experiencing closures **Quantitative empirical analysis of secondary data**
Focus of Studies	**Event:** Military base closures
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** job loss multipliers – how many fewer jobs a closure county had than would be expected if it grew at counterfactual rates
What Mattered?	**Opportunities** • Military base closures had (+) job multiplier effects, likely due to: • Counties receiving technical and financial aid in their reuse (recover) of base property efforts • The sample for this study is not random – counties might have been more-adaptable than average military base closure counties.
Citation	Hultquist, Andy and Tricia L. Petras. 2012. "An Examination of the Local Economic Impacts of Military Base Closures."
Methodology	510 individual counties containing one or more military bases active from 1977 to 2005 + all neighboring counties containing one or more military bases = 1,721 counties observed **Quantitative empirical analysis of secondary data**
Focus of Studies	**Event:** Military base closures
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** Total employment
What Mattered?	**Opportunities** • Places with higher military base personal (own county) prior to the closure of a base experienced (+) * change in county employment

Citation	Isserman, Andrew M., et al. 2007. "Why Some Rural Communities Prosper While Others Do Not."
Methodology	All rural counties in the continental U.S. **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** Attributes of *Prosperous* rural counties
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Poverty rate 2. Unemployment rate 3. High school dropout rate 4. Housing problem rate (% of households with at least one housing condition) *Findings based on t-tests***
What Mattered?	**Opportunities** • Geographic Indicators: · Weak findings for impacts of distance from MSA and location variables. This is encouraging factors like temperature, distances to cities, and employment in the nearby region are beyond the control of local rural development actions. • Economic Indicators · More vigorous private sector · More active and prosperous farm sector · More diversified economies (Herfindahl index) · Lower income inequality • Human and Social Capital Indicators · Higher educational levels on average · Educational attainment among 25-34 year olds is higher · More creative class as percent of occupations · Greater number of associational activity based establishments per capita · More adherent to civically engaged religions · Higher proprietor income per capita (~ of entrepreneurialism) • Demographic Indicators: · Slower growth (2% compared to 7% for less prosperous counties between 1990 and 2000) · Larger elderly population **Barriers** • Economic Indicators · Greater number of government, public sector jobs · Greater number of resource based, value added manufacturing jobs • Demographic Indicators · Greater share demographic changes · more foreign born populations · More foreign-born who arrived in the past decade · More recent in-migration · Greater racial heterogeneity · Rural counties with minority concentrations

Citation	Jolley, Jason, et al. 2019. "The economic, fiscal, and workforce impacts of coal-fired power plant closures in Appalachia Ohio."
Methodology	Adams county, OH – two Dayton power & light coal-fired power plants (in Appalachia Region) **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** coal-power plants
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Employment Impacts – direct, indirect, and induced employment 2. Fiscal Impacts – losses due to lower tangible personal property tax 3. Workforce Impacts – viability of retraining employees in comparable wage jobs
What Mattered?	**Barriers** • Supports finding of limited fiscal resilience of Appalachian communities to exogenous shocks • State fiscal policies limit the ability of localities to recoup lost taxes as a result of plant closures • Access to information for displaced workers – communities have low digital literacy which complicates both occupational transitions as well as the search for job openings • Transportation to technical centers or community colleges where displaced workers can bridge skill
Citation	Kelsey, Timothy, et al. 2016. "Unconventional Gas and Oil Development in the United States: Economic Experience and Policy Issues."
Methodology	Examine the economic experience of past energy booms and of the current unconventional gas and oil development era Survey of key economic issues that tend to arise with energy (oil and gas) development. **Policy evaluation**
Focus of Studies	**Event:** gas and oil development
Community Impact or Outcome Variable(s)	**Policy evaluations:** recommendations and implementation
What Mattered?	**Barriers** • Taxation limited by state government policies • Use of Revenue – local governments have little discretion over use of revenue • Locus of Decision-Making vis-à-vis federal, state, and local governments (preemption of local authority) • Lack of distributional equity over economic benefits (among residents/workers) • High wages in in resource sector for less-skilled workers reduces the incentive for further education and training for less-skilled workers in a vulnerable position **Opportunities (Recommended)** • Use any financial proceeds from activity to fund long-run investments that will strengthen the community so it will be better able to adapt when drilling ends • Do not make long-run financial commitments that may burden the community for a long time • Strive to maintain diversified economy • Protect important environmental and community assets and amenities so they are not harmed during the boom

Citation	Kirschner, Annabel R. 2010. "Understanding Poverty and Unemployment on the Olympic Peninsula after the Spotted Owl."
Methodology	Sub-county areas formed from census tracts in the Olympic Peninsula of Washington State **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** timber and timber dependency
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Poverty (2000) 2. Unemployment (2000)
What Mattered?	**Barriers** • Past poverty (1990) (+) * on current poverty rates • Greater racial/ethnic minority population size (+) * on unemployment rates **Opportunities** • Greater change in the share population with bachelor's degree (-) * poverty rates

Citation	Lobao, Linda, et al. 2016. "Poverty, Place, and Coal Employment across Appalachia and the United States in the New Economic Era."
Methodology	Counties across the US as well as specifically in Appalachian region (ARC) from 1990 to 2010. **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** coal mining employment and change in coal mining employment
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Poverty 2. Household income 3. Unemployment
What Mattered?	**Opportunities** • **Poverty** · Coal employment (-) * from 2000-2010 for US and ARC · Share oil and gas employment (-) * 2000-2010 for all US counties · Growth in coal employment (-) * for ARC in both periods • **Median Household Income** · Share coal employment (+) * in US and ARC for 2000-10 period · Oil and gas mining employment (+) * for US in 00-10' • **Unemployment** · Coal employment (-) * for US and ARC in 00-10' period · Gas and oil employment (-) * for US in 00-10' period · Change in other mining employment for US and ARC in 90-00' and 00-10' · Change in employment for coal (-) * for US and ARC in 00-10' · Change in employment for oil and gas (-) * for US and ARC in 00-10' **Barriers** • **Poverty** · Higher coal employment (+) * 1990-2000 for US • **Median Household Income** · Share coal employment (-) * in US and ARC for 90-00' period · Oil and gas employment (-) * in US for 90-00' period · Growth in oil and gas (-) * for 90-00' period in US • **Unemployment** · Gas and oil employment (+) * for ARC in 90-00' period

Citation	Mayer, Adam. 2018. "A Just Transition for Coal Miners? Community Identity and Support from Local Policy Actors."
Methodology	County and city policy actors in Colorado and Utah **Quantitative empirical analysis of survey data**
Focus of Studies	**Employment by industry:** coal mining
Community Impact or Outcome Variable(s)	**Individuals' attitudes:** policy actors' perceptions of just transition – 1. What accounts for coal's long-term poor fortunes? 2. Who is responsible for paying for policies to assist in the transition away from coal?
What Mattered?	**Opportunities** • A multi-causal explanation – both competition from oil and gas as well as regulations to blame – for decline in coal employment (+) * programs to provide education and training to displaced miners **Barriers** • Community identity tied to extractive industries (-) * to allocating special funds for relocation to new areas to find jobs • Regulations explanation – environmental regulations as cause of coal miner displacement – (-) * that communities will support policies to ensure miners pensions are fully funded
Citation	Partridge, Mark D. et al. 2013. "Natural Resource Curse and Poverty in Appalachia America."
Methodology	Counties in Appalachia region (ARC) over the 1990-2010 period. **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** coal mining employment & mountain top mining
Community Impact or Outcome Variable(s)	**Socio-economic well-being:**poverty rates (2000)
What Mattered?	**Barriers** • Past poverty (1990) (+) * for both US and ARC • Share of coal employment (+) * for ARC counties • Growth in oil and gas employment (+) * for US • Distance to higher-tiered metropolitan areas (+) * **Opportunities** • Educational attainment – high school graduates (-) *

Citation	Partridge, Mark D. and M. Rose Olfert. 2011. "The Winners' Choice: Sustainable Economic Strategies for Successful 21st-Century Regions."
Methodology	Functional Economic Areas for Atlanta, GA; Columbus, OH; Des Moines, IA; and Minneapolis-St. Paul, MN MSAs from 1950-2009 **Quantitative empirical analysis of secondary data & systematic literature review**
Focus of Studies	**Employment by industry:** general indicators of growth
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** population growth (size and density) as well as urbanization intensity
What Mattered?	**Opportunities** • Expanding regional boundaries as more rural areas functionally become tied to urban centers leads to greater within-region cohesiveness • Build from within through retention, expansion, and supporting local entrepreneurship; will likely lead to a more diverse economy than attracting one or two large outside firms/industries. • Regions with an attractive quality of life for high-skilled workers will have advantage in growth
Citation	Pollin, Robert, and Brian Callaci. 2019. "The Economics of Just Transition: A Framework for Supporting Fossil Fuel–Dependent Workers and Communities in the United States."
Methodology	National overview of potential framework for transitioning communities and workers away from fossil fuel-based employment. **Systematic literature review**
Focus of Studies	**Employment by industry:** fossil-fuel dependent employment
Community Impact or Outcome Variable(s)	**Policy evaluations:** transitioning workers away from coal employment
What Mattered?	**Opportunities** • Clean energy investments will produce jobs for electricians, steel workers, machinist, engineers, truck drivers, research scientists, lawyers, accountants, and administrative assistants. • Attritions by retirement – about 85 percent of the necessary job retrenchments can be managed through attritions by retirement when current employed fossil fuel workers reach age 65. **Barriers** • In a 20-year transition period where the coal industry contracts by 60%, 600 younger (<45) workers will need to be laid off

Citation	Poppert, Patrick E. and Henry W. Herzog Jr. 2003. "Force Reduction, base closure, and the indirect effects of military installation on local employment growth."
Methodology	3092 counties in the United States **Quantitative empirical analysis of secondary data**
Focus of Studies	**Event:** military base closures
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** employment in private, nonfarm sectors 1. Employment by industry: hydrocarbon dependent occupations
What Mattered?	**Opportunities** • Military base closures show (+) * on employment two years after base closure • Transfers for educational assistance (+) * on employment rates • Population-employment ratio (+) * effect on employment rates • Population density (+) * on employment rates • Other non-manufacturing, non-services sector employment (+) * on employment • State and Local government employment (+) * on employment • Agricultural sector employment (+) * on employment **Barriers** • Past employment loss (-) * employment • Coefficient of specialization (-) * on employment
Citation	Snyder, Brian F. 2018. "Vulnerability to Decarbonization in Hydrocarbon-Intensive Counties in the United States: A Just Transition to Avoid Post-Industrial Decay."
Methodology	Community level overview of the development of a metric to assess vulnerabilities/resiliencies to decarbonization of the economy to develop an index of vulnerability **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** hydrocarbon dependent occupations
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** vulnerability Index – to assess areas vulnerable to socioeconomic declines due to decarbonization
What Mattered?	**Barriers** • Geographic isolation • High-levels of preexisting socioeconomic disadvantage • Large levels of hydrocarbon employment • Low educational levels may negatively impact communities' ability to adapt • Role and power of labor (workers) is more restricted in the US and is, therefore, unlikely to play a prominent role in the transition. Policy will therefore rely on federal, state, and local governments and policy-makers.

Citation	Sorenson, David and Peter Stenberg. 2015. "The Effect of Military Base Closures on Rural County Economies: An Evaluation of the 1988-1995 Rounds of Cuts."
Methodology	Six counties that meet the criteria of 1. Experiencing a major loss of jobs from military base and 2. Being located in a non-metro area (91-93) and counties active as control group (matching) **Quantitative empirical analysis of secondary data**
Focus of Studies	**Event:** military base closures
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Employment rates 2. Population size Used matching techniques based on sectoral composition of local economy, spatial setting, income levels and sources, and prior growth
What Mattered?	**Barriers** • Counties with military base closures (-) * employment levels relative to those without • Counties with military base closures experienced (-) * population growth compared to those without
Citation	Tsvetkova, Alexandra and Mark D. Partridge. 2016. "Economics of Modern Energy Boomtowns: Do Oil and Gas Shocks Differ from Shocks in the Rest of the Economy?"
Methodology	Counties **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** oil and gas
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Employment across 14 sectors 2. Population size
What Mattered?	**Opportunities** • Oil and gas employment has (+) * spillover into other industry sectors • Metropolitan areas – no link between total employment and energy sector employment **Barriers** • Overall, given that job effects of energy booms are relatively modest in magnitude compared to the scale of the rest of the economy, local economies would be better off if they were to experience broad-based growth rather than energy booms both in terms of multiplier effects and enhanced economic diversity.

Citation	Tsvetkova, Alexandra, et al. 2019. "Self-Employment effects on regional growth: a bigger bang for a buck?"
Methodology	Counties (2001-2013) **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** self-employment vs. wage/salary employment
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** employment growth rates
What Mattered?	**Opportunities** • Estimated benefits for self-employment on employment growth rates (+) * are substantially larger than identical effects of paid employment

Citation	Weinstein, Amanda L., et al. 2018. "Follow the money: aggregate, sectoral and spatial effects of an energy boom on local earnings."
Methodology	Counties by metro and nonmetro status that experience energy expansion compared to other areas **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry:** oil and gas
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Change in total earnings growth 2. Change in Earnings per worker growth 3. Change in employment growth
What Mattered?	**Opportunities** • **Total earnings** · **Nonmetro** · Energy growth (+) * · Change in energy performance in bordering counties (+) * · Industry mix metric (+) · **Metro** · Energy growth (+) * · Change in energy performance in boarding counties (+) * · Industry mix metric (+) • **Earnings per worker** · **Nonmetro** · Energy growth (+) * · Change in energy performance in boarding counties (+) * · Industry mix metric (+) · **Metro** · Energy growth in county (+) · Industry mix (+) • **Employment** · **Nonmetro** · Energy growth in county (+) ** · Change in energy performance in bordering counties (+) ** · Industry mix (+) ** · **Metro** · Energy growth in county (+) ** · Change in energy performance in bordering counties (+) ** · Industry mix (+) ** **Barriers** • **Total earnings** · Nonmetro · Mining employment share (-) * • **Earnings per worker** · Nonmetro · Mining employment share (-) * • **Employment** · Nonmetro · Mining employment (-) *

Citation	Weber, Jeremy G. 2012. "The Effects of a Natural Gas Boom on Employment and Income in Colorado, Texas, and Wyoming."
Methodology	Counties in Colorado, Texas and Wyoming through boom and bust cycles of natural gas extraction **Quantitative empirical analysis of secondary data**
Focus of Studies	**Employment by industry & event:** natural gas
Community Impact or Outcome Variable(s)	**Socio-economic well-being:** 1. Employment 2. Wage and salary income 3. Median household income 4. Poverty
What Mattered?	**Opportunities** • **Employment** · Boom (+) * · Wyoming (+) * relative to Colorado • **Wage and Salary Income** · Boom (+) * · Mining share of earnings (+) * · Wyoming (+) relative to Colorado • **Median Household Income** · Population density (+) * · Ag share of earnings (+) * · Mining share of earnings (+) · Population density of contiguous counties (+) • **Poverty** · Population density (-) * · Manufacturing share of earnings (-) * · Wyoming compared to Colorado (-) *

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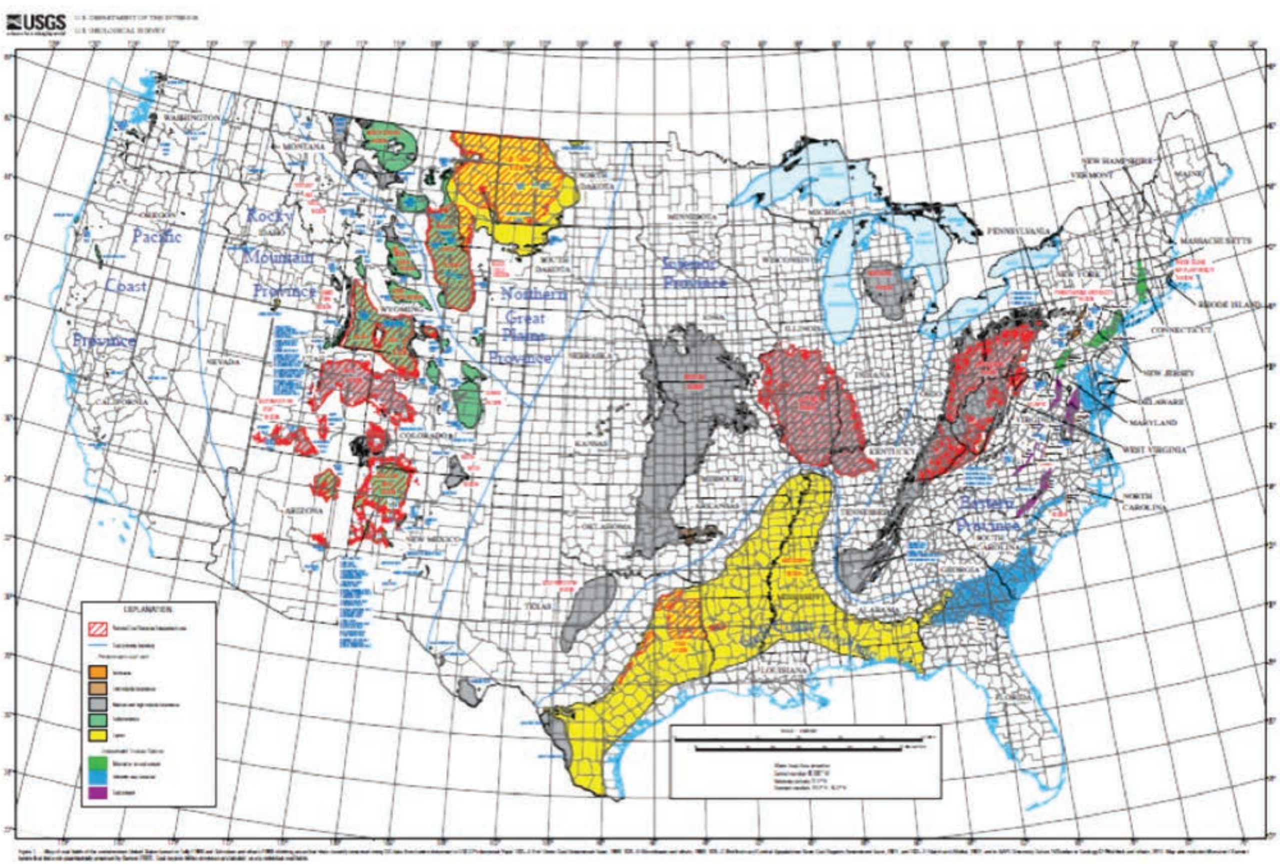
APPENDIX B

Appalachian and U.S. Coal Industry Figures

Appendix B Figure 1:

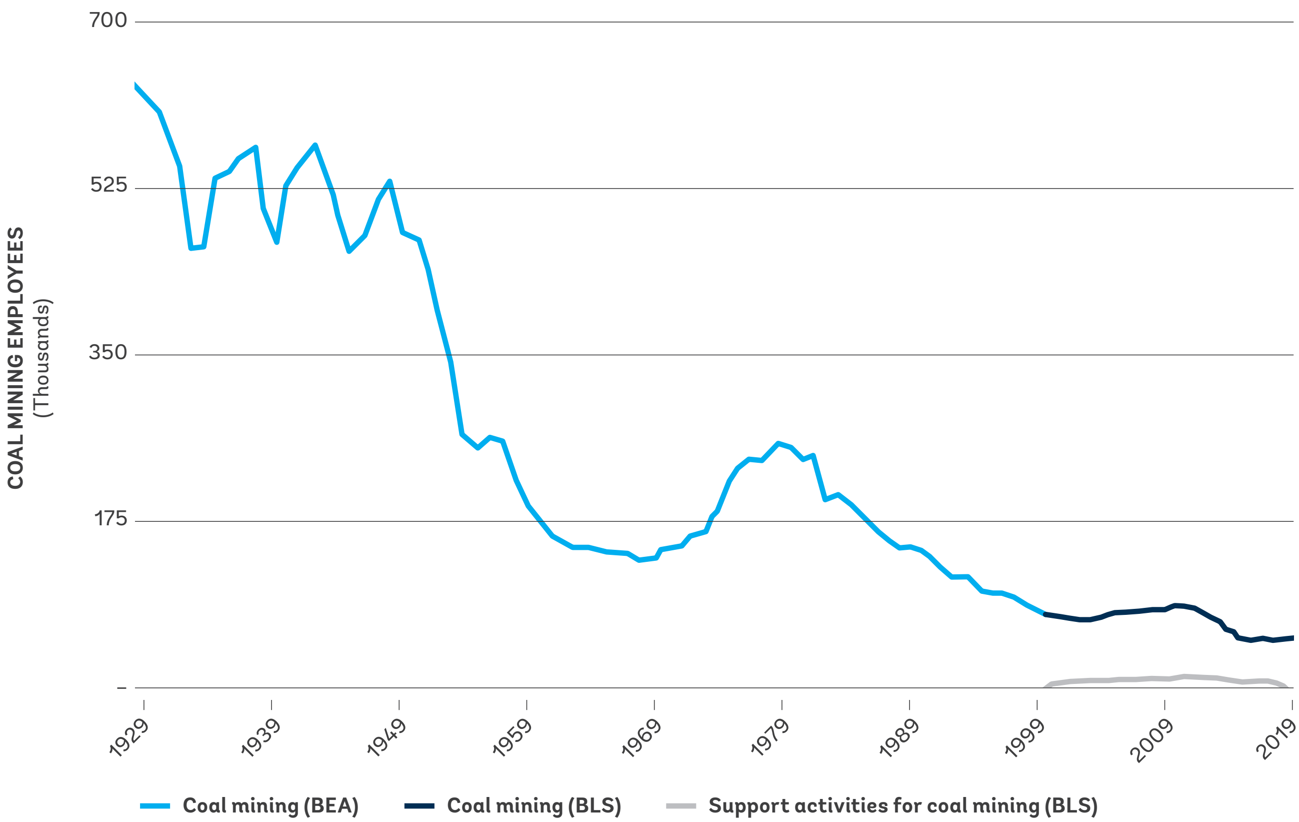
Coal Fields of the United States



Source: Source: East, J.A., 2013, Coal fields of the conterminous United States—National Coal Resource Assessment updated version: U.S. Geological Survey Open-File Report 2012–1205, one sheet, scale 1:5,000,000, available at http://pubs.usgs.gov/of/2012/1205/.

Appendix B Figure 2:

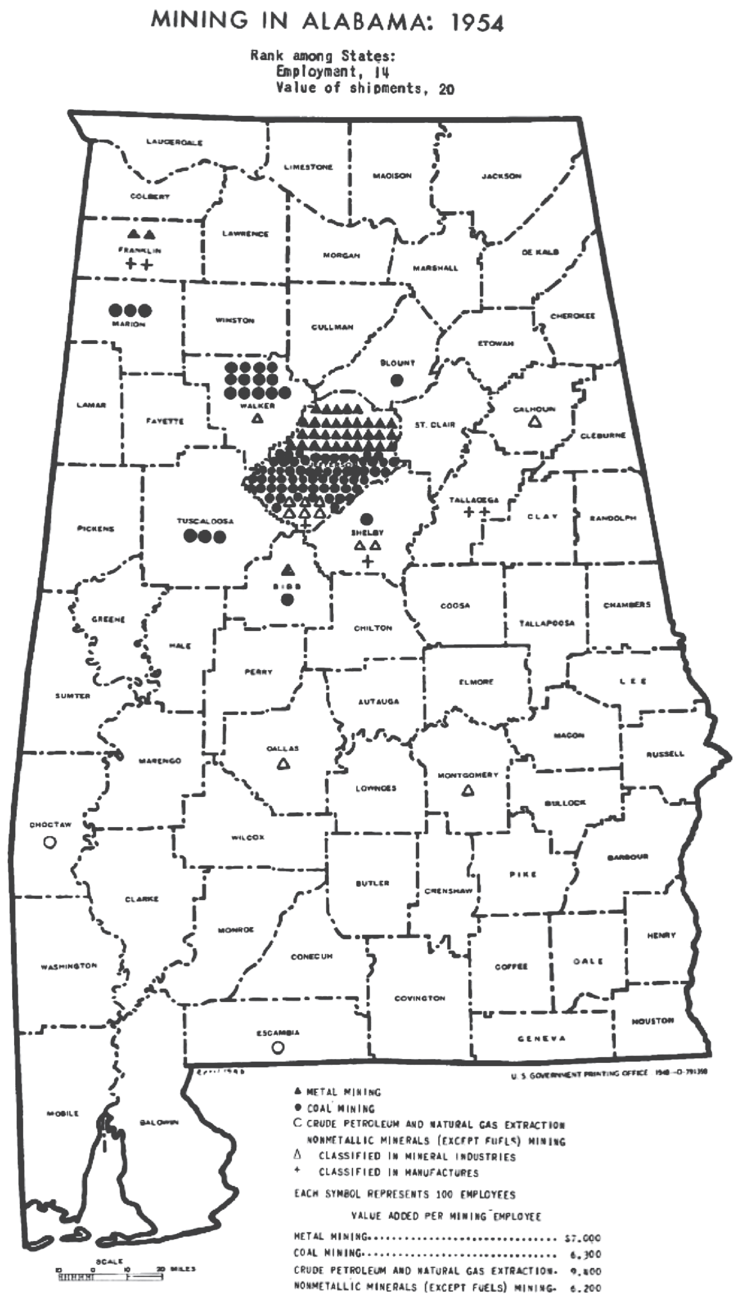
Annual U.S. Coal Mining Employment using BLS/BEA Data



Sources: 1. BEA NIPA Tables 6.4A-D; 2. BLS Quarterly Census of Employment and Wages

Appendix B Figure 3:

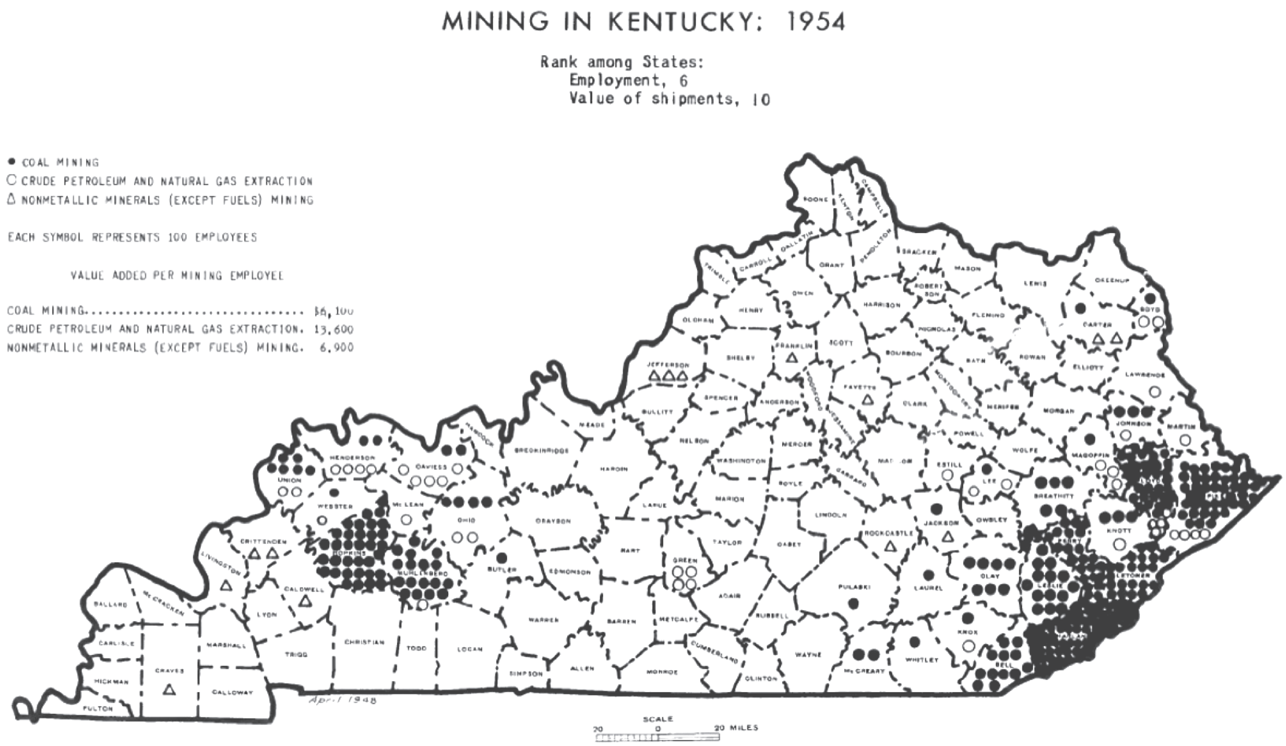
1954 Alabama Mining Industries by Employment



Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs. Note the concentration of coal and metal mining in and near Birmingham in Jefferson County.

Appendix B Figure 4:

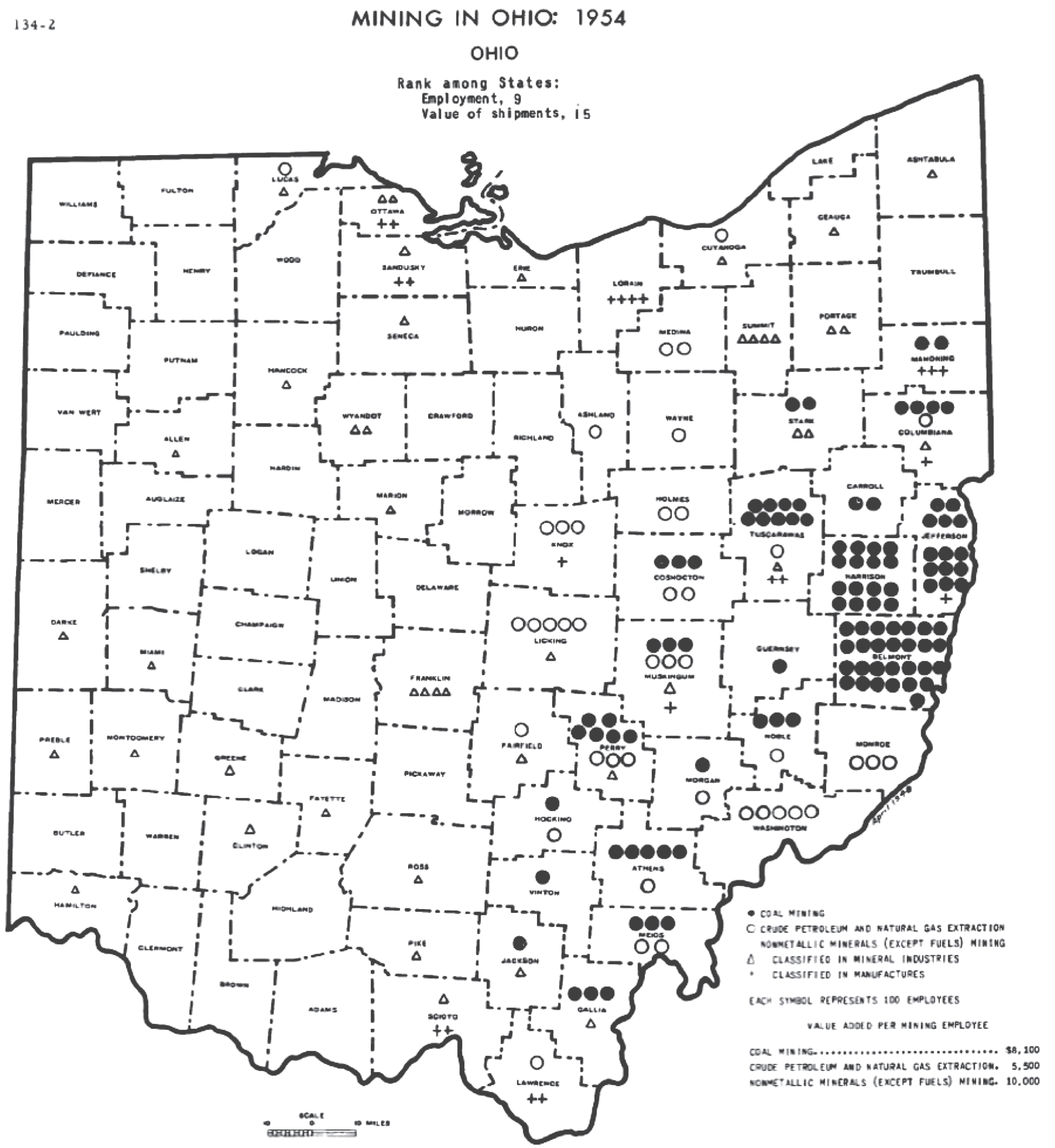
1954 Kentucky Mining Industries by Employment



Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs.

Appendix B Figure 5:

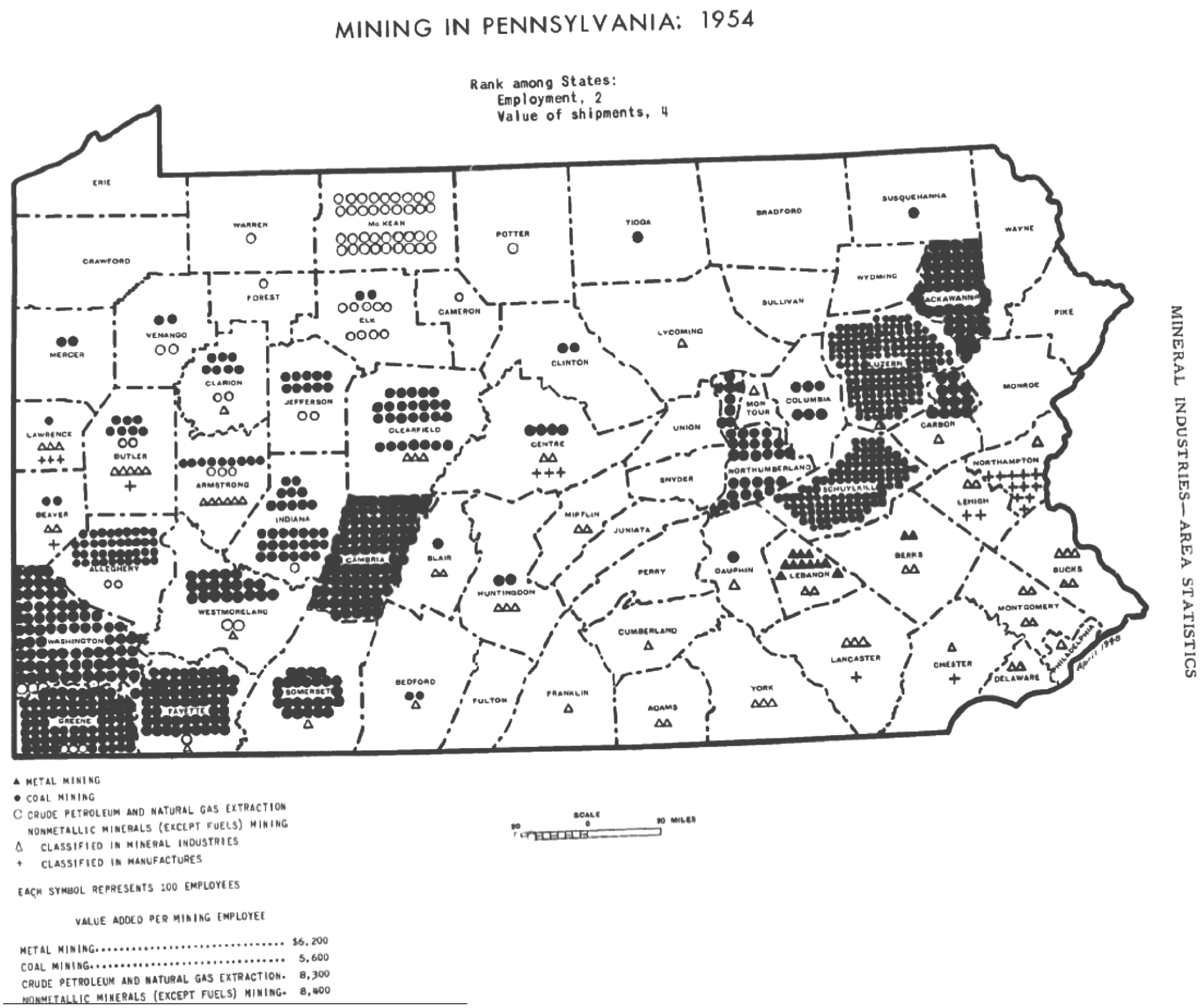
1954 Ohio Mining Industries by Employment



Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs.

Appendix B Figure 6:

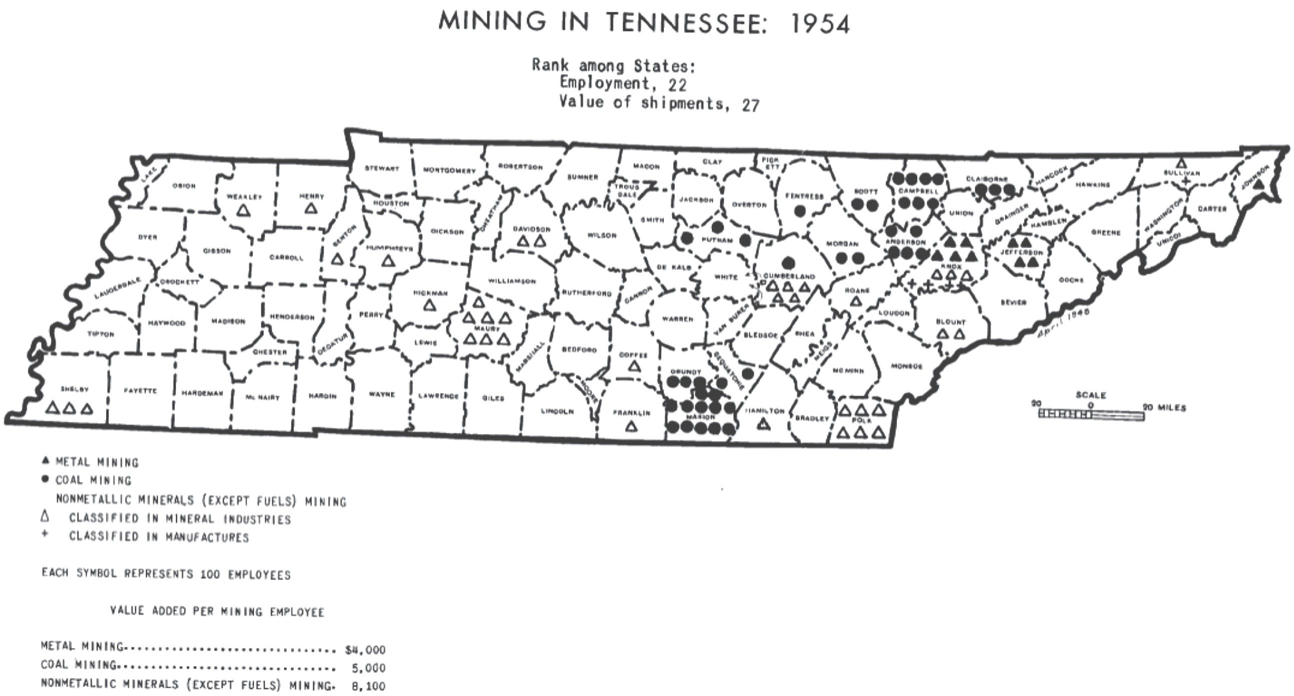
1954 Pennsylvania Mining Industries by Employment



Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Bla Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs. ack circles denote 100 coal-mining jobs.

Appendix B Figure 7:

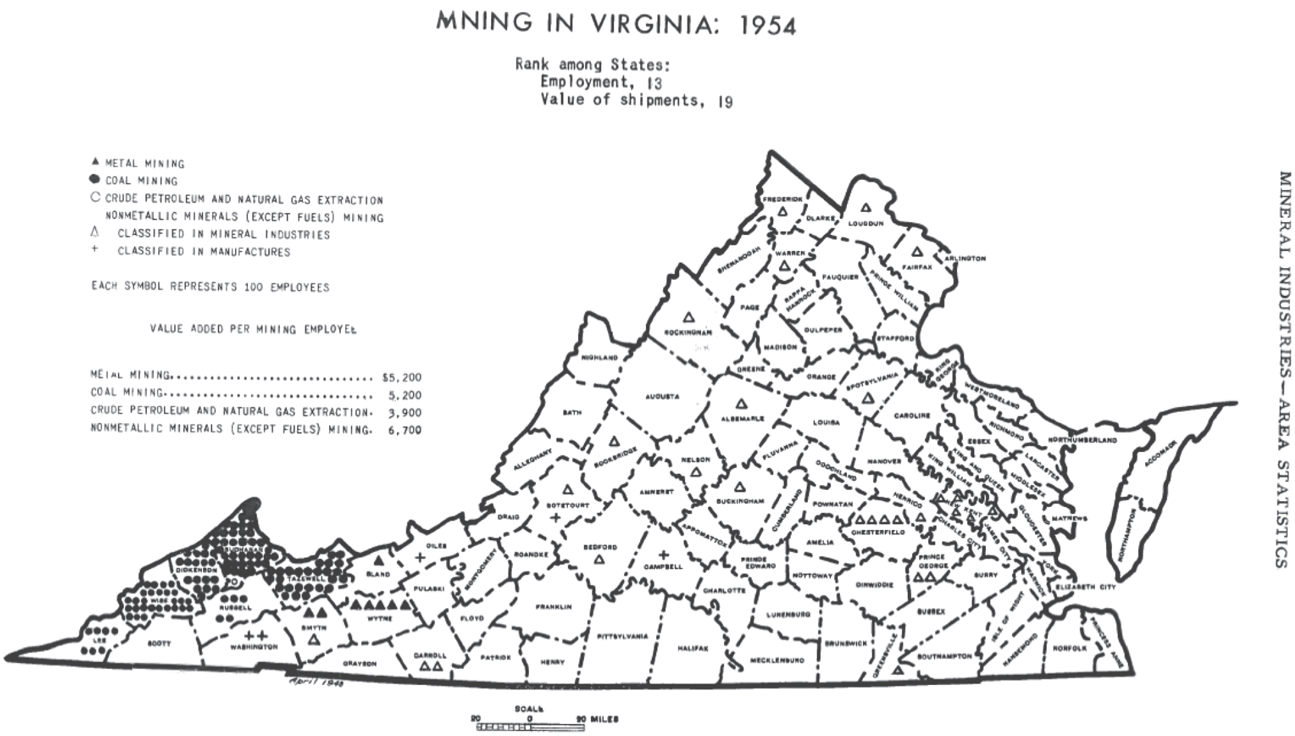
1954 Tennessee Mining Industries by Employment



Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs.

Appendix B Figure 8:

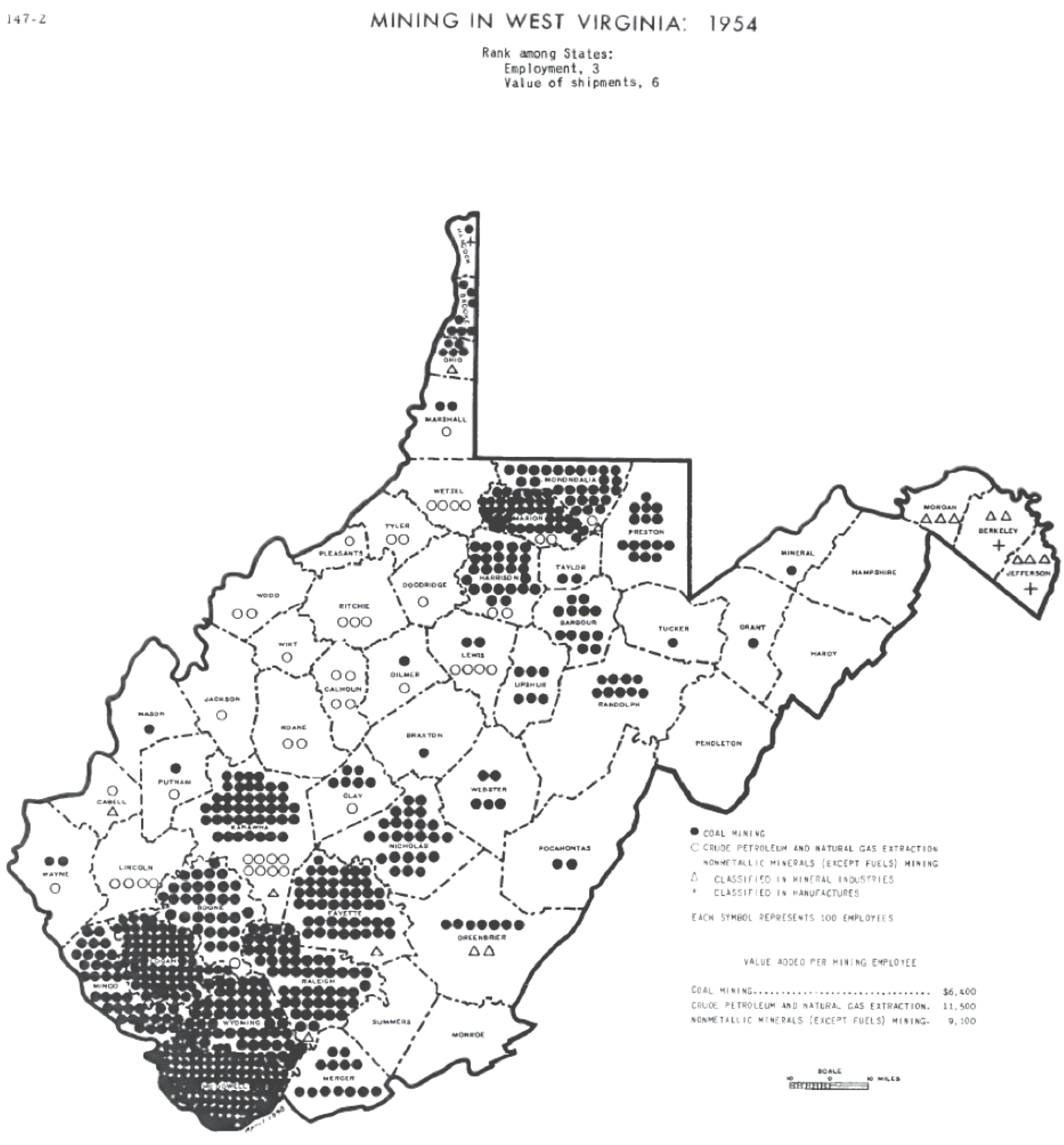
1954 Virginia Mining Industries by Employment



Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs

Appendix B Figure 9:

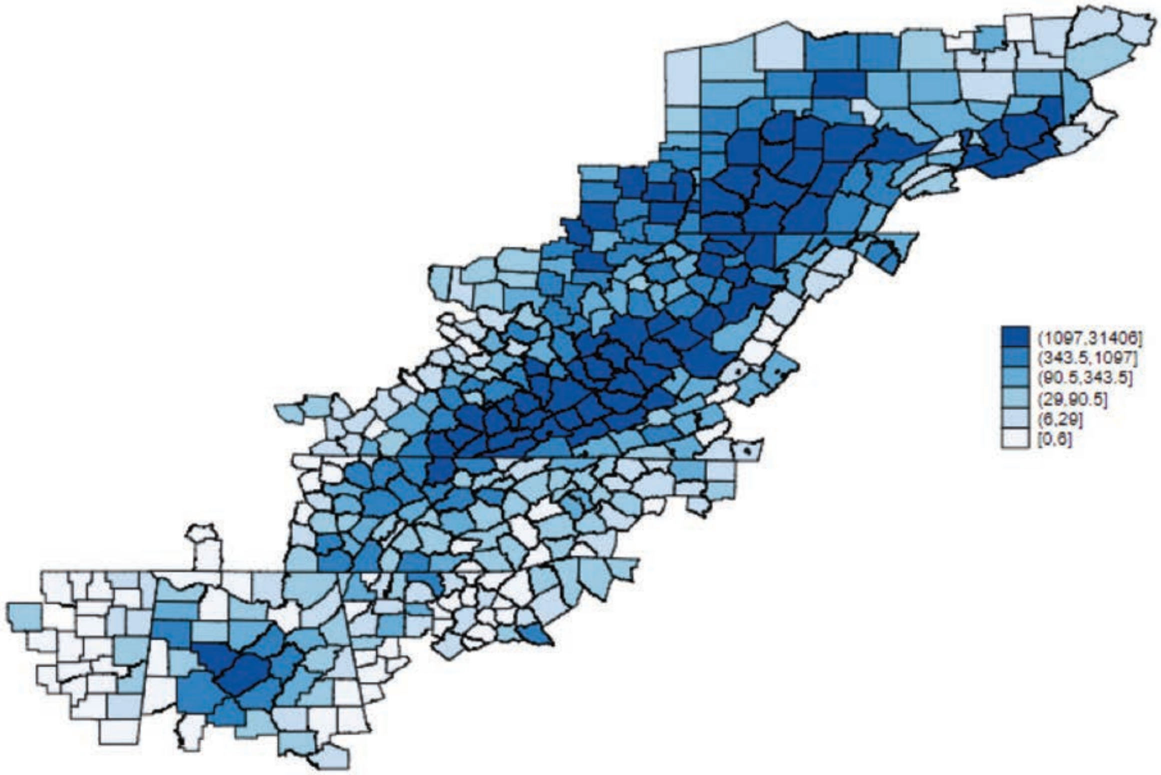
1954 West Virginia Mining Industries by Employment



Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs.

Appendix B Figure 10:

1950 Mining Workers by Place of Residence, ARC Counties



Source: 1950 Census of Population, U.S. Census Bureau

APPENDIX C

Methodologies Used in the Literature to Understand the Economic Impact of Coal Mining

Basic Input-Output Effects. When assessing the expansion or contraction of an industry such as coal mining, one applied model is an "input-out" (IO) model, commonly used by practitioners for estimating economic development impacts. IO models capture three types of effects: direct effects, indirect effects, and induced effects. For example, if the coal industry increases employment by 100 workers and output by 3 million short tons, the direct effects are simply 100 jobs and 3 million tons.

There are then indirect economic effects from the supply-chain input purchases of the coal industry, including corresponding responses as input suppliers make their own purchases of inputs, and so on. And there are induced economic effects from increased spending by newly employed workers in coal (direct) and coal-supply chain (indirect) activities, such as for groceries, household goods, leisure and essential services. The total effects are the sum of the direct, indirect, and induced effects. Although IO models are not necessary for estimating multipliers, they have the advantages of being well known by policymakers and enabling a decomposition of responses outside of the direct industry being considered.

The total economic multiplier can be calculated as the (direct effect + indirect effect + induced effect)/(direct effect), and reflects the total number of (say) new jobs *supported* when the industry *directly* creates (say) 100 jobs. For example, a multiplier of 2.2 means that if the coal industry directly creates 100 new jobs, there are an additional 120 jobs created by indirect and induced effects for a total of 220 supported jobs (i.e., 2.2 × 100). IO results should use the words jobs *supported* rather than jobs *created* because it captures the gross effect plus other (usually) offsetting negative employment effects. There are also corresponding multipliers for other economic outcomes such as output and value added.

IO model estimates can be problematic, however. The question of what happens to total local employment is related to total multiplier effects based on the direct contribution of the new coal industry jobs. However, there are caveats regarding IO estimates that are generally believed to lead to overestimates of the economic impacts. First and foremost is direct reverse causality in which people, including workers, move into a local area for (say) quality-of-life or in response to the creation of jobs. Reverse causality leads to multiplier estimates being overstated as new residents create added demand for local firms. Second, there are crowding-out effects. For example, if there is a positive expansion of the local coal industry, this will bid up wages and land prices as the local economy expands, which leads to other local firms hiring fewer workers or perhaps going out of business due to higher land and labor costs. Crowding-out effects are reinforced if the expansion of economic activity in turn increases local housing costs, causing some local residents to relocate, which further leads to offsetting reductions in local economic activity.

There are other offsetting effects in IO estimates. Betz et al. (2015) found that local self-employment was negatively impacted by greater coal-mining intensity, which reduces entrepreneurship and long-run economic growth. Likewise, they found that greater coal intensity negatively impacted long-run population growth, all else equal. The population results are consistent with people not wanting to be near coal mining, perhaps due to environmental reasons. Overall, these effects *offset* any positive *gross* economic impacts of coal mining, compounding the overestimation of economic impacts by IO models.

The presence of agglomeration economies can lead IO models to *underestimate* multiplier effects. For example, positive feedback loops between customers and suppliers can create positive linkages that increase the size of economic impacts within an agglomeration. The best examples are found in the New Economic Geography (NEG) literature (e.g., Krugman 1991). Yet, even in NEG models, congestion effects eventually limit the size of a city as it becomes crowded, polluted, imposes longer commutes, etc.

Other basic shortcomings of IO models are unavoidable. For one, the underlying coefficients such as IO technical coefficients that show how much input from industry *i* is used in the production of industry *j*. In the case described below, these production-technology coefficients for each local area are estimated using national IO coefficients with some relatively minor adjustments—i.e., assuming the average national technology applies to every county despite the vintage of the capital investments. Lazarus et al. (2002) find evidence that errors in measuring local production technology is a key reason for commercial IO models such as IMPLAN to inaccurately estimate economic impacts. Another method is to survey local businesses regarding their production technologies and purchasing decisions. While survey approaches capture local production idiosyncrasies, they still involve measurement error and are costly.

There are a host of other coefficients and parameters that must be estimated in an IO model. Foremost is the regional purchase coefficient (RPC), which estimates how much input purchases by a particular industry can be provided locally. The RPC can be estimated multiple ways such as using relative production intensities (location quotients), econometric estimation, or surveys, but regardless of the approach, all are prone to measurement error. Commercial IO models can produce literally hundreds of direct, indirect, and induced effects by industry, but such estimates can give inexperienced users a false sense of precision in the results because unlike statistical analysis, there is no indication of the degree of precision, e.g., standard errors.

Statistical Approaches. There are also statistical or econometric estimates of the multiplier-impacts of the energy industry, which is a more recent innovation. Statistical methods have the advantage of taking into account all of the net positive and negative offsetting effects and can be casual estimates if done correctly. Studies typically find energy-sector and average-industry multiplier effects to range between about 1.3 and 2 for county-level economic impacts (e.g., Tsvetkova and Partridge 2016), magnitudes that are similar or slightly smaller than IO estimates. For larger geographical areas such as metropolitan areas, states, or the entire nation, multipliers tend to increase as economic spillovers generate added economic activity through commuting or purchases of inputs.

Coal Industry Supply-Chain in the Broader U.S. Economy. In the case of the coal industry, one key input is heavy coal-mining equipment, which tends to be manufactured throughout the world. Such heavy-mining equipment is not typically available in geographically remote, sparsely populated areas such as central Appalachia or the PRB (e.g., Caterpillar's main manufacturing site is in Peoria, IL). In the U.S., the big heavy equipment that extracts and transports coal around a mining site is manufactured by the (relatively small) Construction Machinery Manufacturing industry (NAICS 333120) for which coal mining is just a sliver of its output, generating only modest indirect employment effects. The other main coal mining equipment manufacturing industry is Mining Machinery and Equipment Manufacturing (NAICS 333131), which includes machinery for all mining except oil and gas. This industry only employed 10,000 U.S. workers in 2019. There are other industries that supply inputs for coal mining, but they all employ small numbers across the U.S. Thus, the relative impact of coal mining in terms of U.S. employment up the supply chain is limited, given that there are approximately 160 million Americans in the labor force.

Three large buyers of coal are the foundry industry for iron and steel (NAICS 33111), Other Petroleum and Coal Products Manufacturing (NAICS 32419), and fossil fuels electric power plants (NAICS 221112). The iron and steel industries have increasingly dispersed across the country with the rise of mini-mills in the last 40-50 years. Even so, foundries only employed 64,000 in the U.S. in 2019 and it is unclear how, if at all, it would be affected if its coal inputs were ever cut off. Likewise, Other Petroleum and Coal Products are also dispersed throughout the country. Examples are products produced in coke ovens such as asphalt and roofing materials. It is also uncertain how these products would be substituted if coal was no longer available. For example, other materials may replace asphalt, whereas shingles can use a host of substitutes such as wood or petrochemical plastics. The employment effects are further limited because coal is not necessarily the main feedstock for some firms in this industry including those who produce lubricants. Even so, this industry only employed about 16,000 in 2019.

Power plants serve as the main downstream buyer of coal. Generally, coal-burning power plants are not located at the coal mine itself, though there are exceptions such as at Colstrip, Montana. As described below, coal-burning power plants have been under pressure for the last decade due to low natural gas prices and the falling cost of alternative electricity sources such as solar and wind. Further weighing down coal is the large number of coal-burning power plants built 40 or more years ago, which are highly inefficient and environmentally problematic, leading to wide-scale closures of older coal power plants. This engendered a precipitous decline in fossil-fuel power-plant employment from 137,000 in 2009 to 82,000 a decade later. Much of these job losses reflect simple efficiency gains associated with reallocation to modern technology that is also less labor-intensive. Some job losses may stem from the fact that alternative energy generation may take place in locations far from traditional power plants. Nonetheless, reallocating away from coal-electricity power generation to other sources may have a small net effect on U.S. employment because the jobs lost in the coal-electricity supply chains would be offset to some degree by employment gains in renewable energy or natural gas-electricity supply chains.

Case Study of Coal-mining Multipliers in Virginia. To give a sense of the size of localized impacts on coal communities from changes in coal mining employment, we examine the case of far southeast Virginia coal country. Virginia has 7 counties that produce coal, three of which – Buchanan, Wise, and Dickenson counties – account for well over 80% of the state's total coal production. The other four counties are Lee, Russell, Taxewell, and Scott Counties (Farren and Partridge, 2015). All are part of the ARC.

Farren and Partridge (2015) analyzed the impact of the coal industry on Virginia's budget for state and for local "coal" counties. To do this, they estimated coal-mining's impact on

Virginia's economy, both in coal country and the state. As noted above, as the geographical area expands, the multiplier increases because of spillovers such as from coal-mining input purchases in (say) Richmond, VA. However, IO models do not pick up displacement effects. For example, if there is a new factory that opens up in southeastern Virginia coal country to supply the coal industry, it may put out of business a competing factory outside of coal country that also supplies the coal industry.

Farren and Partridge (2015) (herewith FP) used proprietary IO software IMPLAN to estimate these effects. IMPLAN is a popular, relatively low-cost software, based on IO models and can be purchased for states, metropolitan areas, and for multiple or single counties. As described above, IMPLAN like other commercial models lack any notion of "uncertainty" of the estimates (IMPLAN could incorporate a Monte Carlo framework to bootstrap standard errors).

FP considered coal-mining effects for three regions: (1) all of Virginia; (2) the broader "7-county" coal region; and (3) the narrower "3-county region" most heavily coal-dependent. Specifically, FP assessed the impact of a $1 million increase in coal production in 2011 on the three Virginia study regions. The expected pattern emerges, namely that multipliers are larger when expanding from the 3-county core coal mining region to the 7-county region, and then to the entire state. For example, the employment multiplier is 2.60 for Virginia and 1.74 for the core 3-county region, suggesting that 100 new coal mining jobs is respectively associated with a total increase of 260 and 174 jobs supported by coal in Virginia and in the core 3 coal counties. For output multipliers, FP estimate that a $1 million increase in coal-mining output in the core 3-county coal region is associated with supporting an output increase of $1.29 million and $1.62 million for the 3-county region and for the state, respectively. Note, the results likely overstate multipliers and estimates have statistical error.

APPENDIX D

Regression Model Description and Results

The following briefly describes the regression model we employed. Our dependent variable is the percent change in population between period t and period t+1. The sample is the 420 ARC counties and other counties within 100 miles from the ARC region, yielding a sample of 1070 counties. Adding the additional buffer counties provides more variation in outcomes and in the explanatory variables and helps ensure we are not estimating an equation on a selected group of counties that are lagging by definition—i.e., the ARC was set up to address lagging development. Thus, we estimate the following very simple regression model:

$$\Delta population_{t,t+j} = a_0 + a_1 Mining\ Employment\ Share_t + a_2 (Mining\ Employment\ Share_t)^2 + a_3 Population_t + Metropolitan_{1973} + NonAppalachian + Region$$

Where NonAppalachian is an indicator equaling 1 if the county is in the 100 mile buffer zone outside of the ARC's region. We did not extend the buffer farther, say to include the whole country, because we thought that would introduce significant heterogeneity into the model. Region is a vector of two indicator variables for ARC regions. Population is the log of the initial-period population and Mining Share of the Labor Force is the share of the county's civilian labor force employed in mining. Thus, the mining share variable proxies for the importance or dependence the local county has on the mining sector. We caution that these regressions are descriptive, not causal.

The rationale for including the non-ARC indicator is that we anticipate that these counties will grow faster than ARC counties, because if not, they likely would have been included in the ARC in the first place. The North and South ARC dummies are the specific ARC region. The more economically disadvantaged central ARC region is the omitted group. Appendix D Figure 1 provides a map of these ARC regions and Appendix D Figure 2 is a map of the ARC designation of distressed to competitive counties to show that coal country has some of the weakest economies in Appalachia.

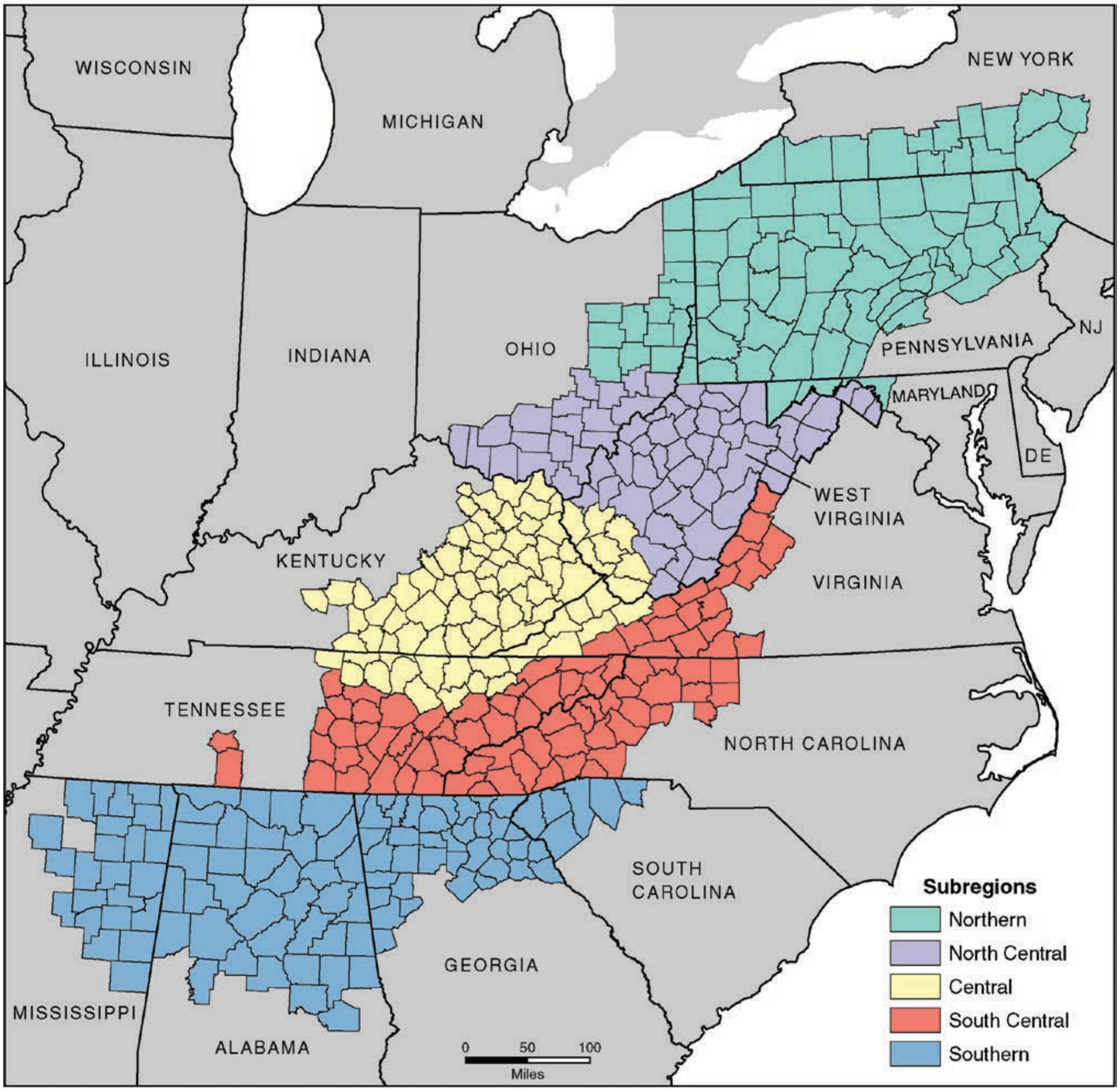
The initial log population is a measure of agglomeration economies that might support faster local economic growth. Likewise, the indicator for being part of a metropolitan area in 1973 is another measure of both agglomeration economies and more generally for rural areas, whether the county has commuting opportunities for their workforce.

Before describing additional steps in identifying successful transition counties, we briefly discuss the empirical results. Appendix D, Table 1 reports the descriptive statistics in column (1) and then regression results for 1950-2018, 1980-2018, and 2000-2018 in columns (2)-(5). The results for these models end up being the most important in our analysis.

The regression results are generally expected and consistent across models. For example, the mining share coefficient is negative and statistically significant in all three cases, while the squared mining share coefficient is positive and statistically significant in two out of three cases. For the 1950-2018 model, taking the derivative of mining share and its square yields a positive marginal relationship on population growth with a share > 42 percent, and in the 2000-2018 model, the marginal association turns positive after the mining share of the labor force surpasses 12 percent (the 1980 mining share squared coefficient was statistically insignificant in the 1980-18 model). Not surprisingly given the rise of the Sunbelt, the ARC South indicator is highly positive in both periods. Likewise, the MSA indicator shows that metropolitan counties were associated with faster growth.

Appendix D Figure 1:

ARC Defined Regions

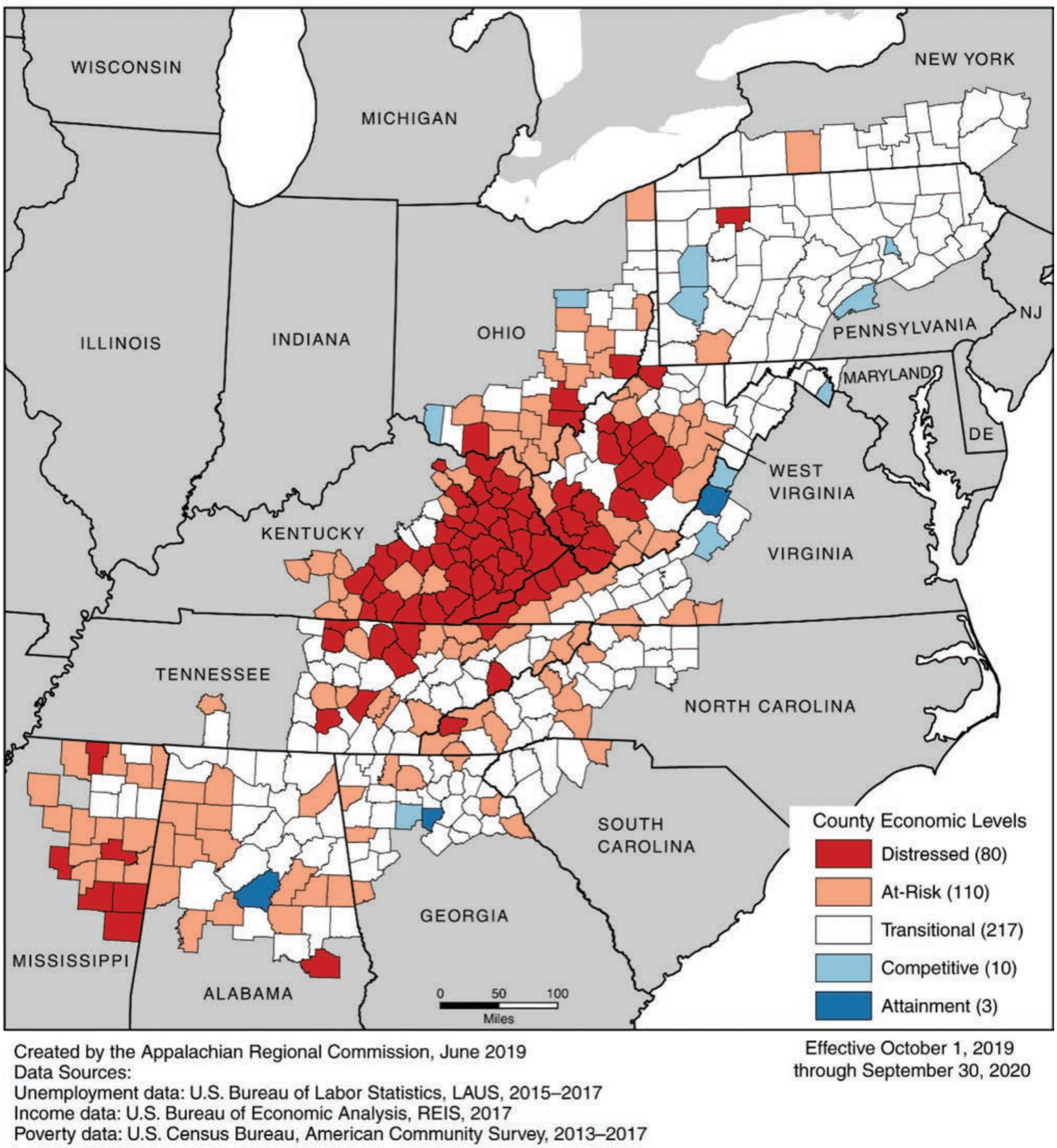


Map by: Appalachian Regional Commission, November 2009.

Source: https://www.arc.gov/assets/maps/related/Subregions_2009_Map.png. (Downloaded May 4, 2020). The regression model merges north and northcentral and southcentral with south for the regression analysis.

Appendix D Figure 2:

ARC Distress Indicators of Economic Well-Being



Source: https://www.arc.gov/research/MapsofAppalachia.asp?MAP_ID=149. (Downloaded May 4, 2020). ARC county rankings from distressed, or least well off, to competitive, or best well off counties. The measures are a weighted average of the county's unemployment rate, official federal poverty rate, and per-capita market personal income. For more details, follow the ARC link above.

Appendix D Table 1:

Regression Estimates for Selected Time Periods

(1) Summary Stats		Regression results		
%Population Growth 1950 to 2018	94.46 (215.02)	**(2)** Population Growth 1950 to 2018	**(3)** Population Growth 1980 to 2018	**(4)** Population Growth 2000 to 2018
%Population Growth 1980 to 2018	30.54 (63.53)			
%Population Growth 2000 to 2018	6.67 (17.69)			
%MiningEmpShare1950	3.40	-5.34***		
	(8.33)	(-4.18)		
MiningSqr1950	79.17	0.064***		
	(367.51)	(2.82)		
Log Pop1950	67,616	-0.000181***		
	(189,522)	(-5.20)		
%MiningEmpShare1980	6.97		-3.22***	
	(6.35)		(-4.85)	
MiningSqr1980	88.9		0.0260	
	(196.72)		(1.55)	
Log Pop1980	88,434		-4.52e-05***	
	(20,2230		(-5.094)	
%MiningEmpShare2000	0.78			-3.58***
	(1.89)			(-7.60)
MiningSqr2000	4.19			0.148***
	(22.83)			(4.57)
Log Pop2000	101,195			7.67e-08
	(216,298)			(0.0333)
Metro1973	0.27	197.4***	32.27***	10.11***
	(0.45)	(7.857)	(4.511)	(6.290)
NonAppalachian	0.61	10.17	5.40	0.097
	(0.49)	(0.66)	(1.35)	(0.092)
ARC North	0.16	-2.53	-5.20	-3.19**
	(0.36)	(-0.16)	(-1.24)	(-2.33)
ARC South	0.71	68.57***	32.33***	8.10***
	(0.45)	(4.67)	(7.35)	(6.21)
Constant		9.75	20.36***	0.76
		(0.60)	(3.54)	(0.55)
R-squared		0.18	0.16	0.15
Observations		1,070	1,070	1,070

Std. dev. in parentheses and Robust t-statistics are in parentheses. The descriptive statistics are in levels, not in logs in the cases that the table states log in the variable names, though the regression results report the results using log as described in the empirical implementation section.
**** p<0.01, **p<0.05, *p<0.1*

APPENDIX E

Further Details on "Successful" County Selection Robustness Analysis and Data

We test the robustness of our selection methodology by comparing our results to other variables commonly used to measure successful post-coal economic development. To do this, we compare our four "successful transition" counties to other mining-intensive counties with respect to four key indicators associated with well-being: population growth rate, mining and coal employment shares, median household income, and poverty.

We use descriptive analysis to compare outcomes of our four counties to the top-10, median-10, and bottom-10 ranked performers (based on population growth) within the 99 mining-dependent ARC counties. Results are reported below, with the following color coding (which corresponds to colors in Figure 4.2): yellow denotes the four successful-transition coal mining counties, orange denotes the top-ten fastest growing mining-intensive counties (excluding the four successful counties), green denotes the 10 median-performing counties in terms of population growth, and blue denotes the 10 worst-performing mining-intensive counties.

Appendix E Table 1 reports the four groupings' population growth over various sub-periods. The groupings are highlighted in different colors for ease of comparison. At the bottom of each group is that group's average and standard deviation. At the very bottom is the variable's average and standard deviation for: all U.S. metropolitan counties (1973 definition), all U.S. nonmetropolitan counties, all ARC metropolitan counties (1973 definitions), and all ARC nonmetropolitan counties (Table 3 excludes U.S. averages). Table 2 also shows the periods for which the successful transition counties exceed their respective metro/nonmetro ARC average population growth rates. These cases are shaded grey. The 2000-2010 nonmetro case is the rare one when the U.S. average is exceeded by the ARC average. In that case, the cell is grey cross-hatched when county population growth exceeds the U.S. average but trails the ARC average.

Appendix E Table 2 presents the mining share of the labor force for each decade spanning 1950 to 2010, along with the coal-mining nonfarm employment share in 2016. Recall that the denominator is the civilian labor force. The mining share is based on the county of residence. Conversely, the coal-mining share is a place-of-work measure based on the actual county where the worker is employed. The difference between the mining share and coal-mining share, besides broader industry classifications, is commuting patterns. By considering the county of residence in the mining share variable, we account for counties that are mining dependent even if workers are employed elsewhere. Yet, to determine whether a local coal industry exists in the county, we use place-of-work data from the *Census of Mineral Industries.*

Median household income is the third category of comparison. As shown in Appendix E Table 3, median household income in the four successful coal-transition counties is below levels in the top-10 performing mining counties, but no clear time trend is observed. Because the top-10 performers tend to be more populated, a better comparison is to the median-performing counties given their similar populations. In 1960, successful transition counties had a median household income 32% greater than median-performing counties, and this margin falls to 23.3% in 1990, and stabilizes at 22.8% higher in 2018. While the four successful-transition coal counties had higher median-household income over the entire period, the median-performing counties made relative gains over time. As noted above, median-performing counties were losing population unlike relatively successful coal-transition counties; this income pattern may therefore reflect the effects of falling labor supply in median-performing counties rather than a relative improvement in local well-being that attracts migrants. The four successful transition counties made impressive gains in median household income compared to the bottom-10 performers, which were hemorrhaging population. Falling relative income in conjunction with falling population implies that labor demand decreased more than labor supply. One explanation could be that more deindustrialization took place in the poorest-performing mining-intensive locales. As noted in the SEM discussion in Appendix C, these patterns are unsurprising because average income shows no clear trend due to regional compensating differentials.

Poverty is the final category of comparison. Appendix E Table 4 shows poverty rates from 1960 to 2018, revealing very high rates, and some surprising patterns. In terms of their levels, median-performing counties had remarkably high average poverty rates in 1960, averaging 20 percentage points above the average rate in the four successful-transition counties, which at 44.1%, was already alarmingly high. The highest-performing and poorest-performing mining-intensive counties also had high initial poverty rates, respectively averaging 35.6% and 29.8%, both lower than the successful-transition counties. These figures reflect the significant poverty across Appalachia. For comparison, the overall U.S. poverty rate was only 22.2% in 1960. It is therefore not surprising that in 1965, Congress enacted the ARC to address the region's severe and persistent poverty.

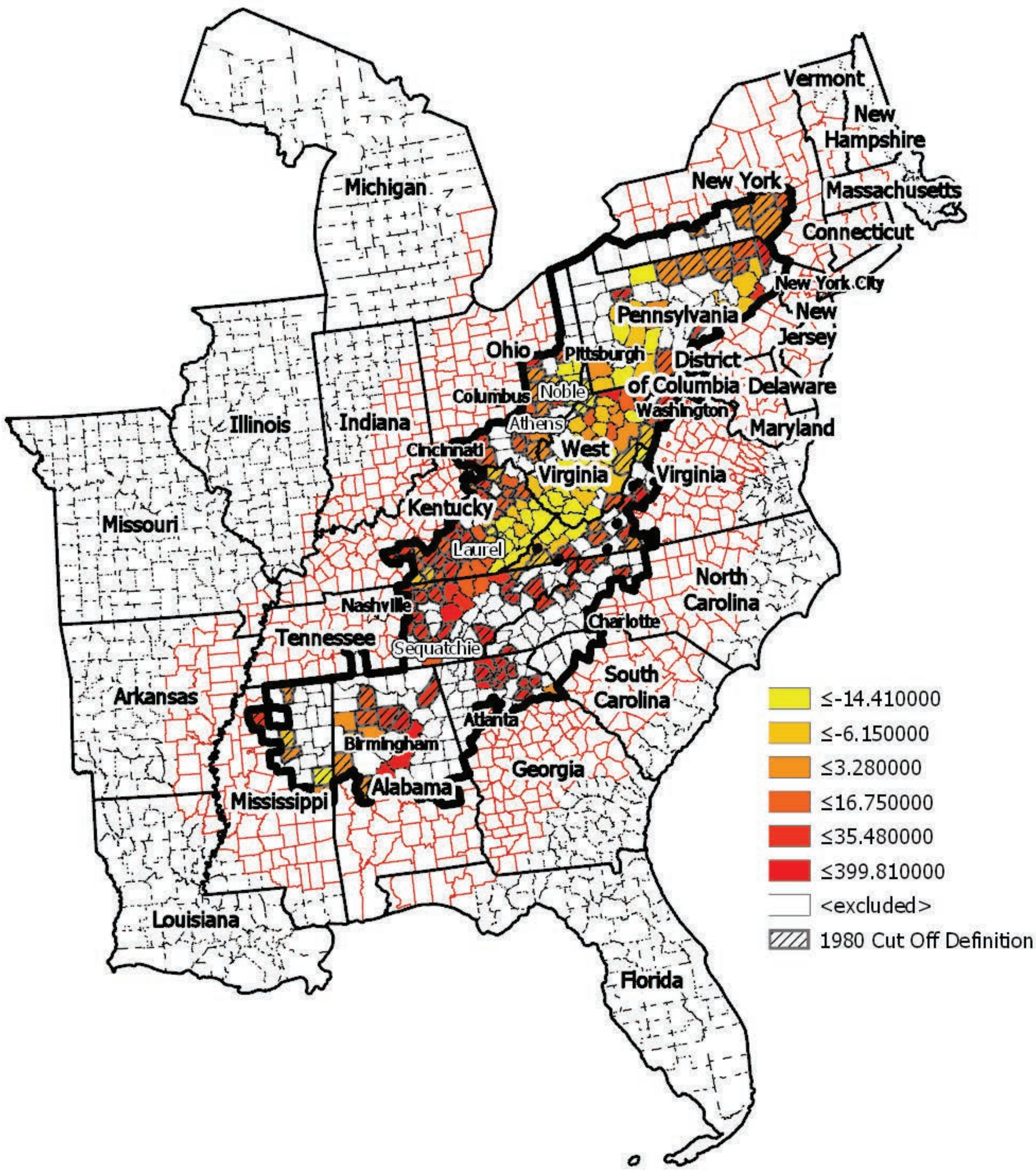
Between 1960 and 1980, Appalachia made remarkable progress. In 1980, the average ARC metropolitan county poverty rate averaged 12.7 percent (vs. 30.4 percent in 1960) and the nonmetro county poverty rate averaged 19.1 percent (vs. 45.9 percent in 1960). The overall 1980 U.S. person rate equaled 13 percent. After 1980, however, progress stagnated as overall U.S. income inequality began to rise, and the ARC region actually lost ground. All four comparison groups experienced increased poverty rates between 1980 and 2018. And the relatively weakest-performing counties turned in the worst performance between 1960 and 2018.

Considered together, this comparison exercise suggests that our selection criteria and methodology yield results that are relatively consistent with standard "success" measures.

We also examine performance with respect to alternative socioeconomic variables including population size, human capital, local economic structure, population age structure, social capital, government capacity and other socio-economic characteristics. Results are reported in Appendix E Tables 5-12 below.

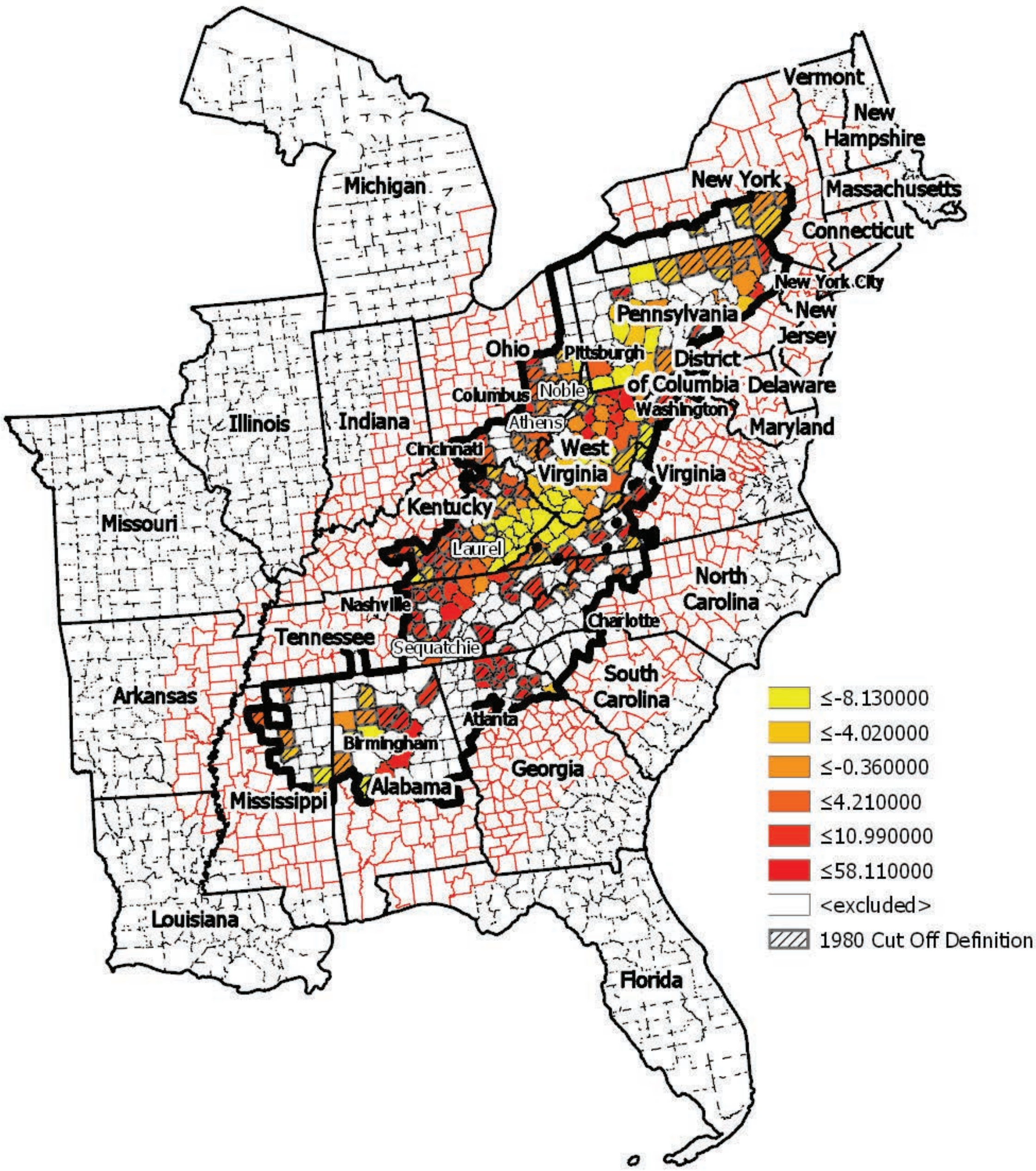
Appendix E Figure 1:

1980-2018: ARC %Population Growth in 1950 and 1980 Mining-Intensive Counties



Appendix E Figure 2:

2000-2018: ARC %Population Growth in 1950 and 1980 Mining-Intensive Counties



Appendix E Table 1:

Successful and Selected Counties' % Population Growth Rate 1950-2018

County	State	FIPS	MSA 73	MSA 13	%Δp 5018	%Δp 5060	%Δp 6070	%Δp 7080	%Δp 8090	%Δp 9000	%Δp 0010	%Δp 1018
Successful Coal Transition Counties												
LAUREL	Kentucky	21125	0	0	133.3	-3.5	10.0	42.3	11.4	21.4	11.7	2.2
SEQUATCHIE	Tennessee	47153	1	1	159.1	4.0	7.0	35.9	3.0	28.3	24.7	3.9
ATHENS	Ohio	39009	0	0	43.8	2.5	16.8	2.8	5.6	4.5	3.8	2.1
NOBLE	Ohio	39121	0	0	22.9	-6.5	-5.0	8.5	0.2	24.0	4.2	-1.4
Average					**89.8**	**-0.9**	**7.2**	**22.4**	**5.1**	**19.5**	**11.1**	**1.7**
Std Dev					**66.5**	**5.0**	**9.1**	**19.7**	**4.8**	**10.4**	**9.8**	**2.2**
Ten Best Performing Mining-Intensive Counties												
GREENE	Pennsylvania	42059	0	0	-18.2	-13.2	-8.5	12.2	-2.3	2.8	-5.1	-3.8
PERRY	Ohio	39127	0	1	24.1	-3.9	-1.5	13.1	1.7	8.0	5.9	-0.3
FAYETTE	Pennsylvania	42051	0	1	-30.3	-10.8	-8.7	3.1	-8.8	2.3	-7.9	-3.4
PICKENS	Georgia	13227	0	1	248.2	0.5	8.1	21.1	23.9	59.3	28.1	4.7
SHELBY	Alabama	1117	1	1	595.8	5.8	18.4	74.3	49.9	44.2	36.3	8.2
MONONGALIA	West Virginia	54061	0	1	73.1	-8.5	14.6	17.8	0.6	8.4	17.8	9.2
CUMBERLAND	Tennessee	47035	0	0	210.6	1.4	8.4	38.3	21.1	34.7	20.0	4.4
CLEARFIELD	Pennsylvania	42033	0	0	-6.7	-5.1	-8.5	12.0	-6.6	6.8	-2.1	-1.8
INDIANA	Pennsylvania	42063	0	0	11.2	-2.3	5.4	16.1	-2.5	-0.4	-1.1	-3.3
SCHUYLKILL	Pennsylvania	42107	0	0	-28.4	-13.7	-7.5	0.3	-5.0	-1.5	-1.6	-3.0
Average					**89.8**	**-0.9**	**7.2**	**22.4**	**5.1**	**19.5**	**11.1**	**1.7**
Std Dev					**66.5**	**5.0**	**9.1**	**19.7**	**4.8**	**10.4**	**9.8**	**2.2**
Ten Median Performing Mining-Intensive Counties												
LEE	Virginia	51105	0	0	-33.2	-28.5	-21.3	27.7	-5.6	-3.7	8.2	-5.5
LESLIE	Kentucky	21131	0	0	-32.6	-29.6	6.2	28.0	-8.3	-9.1	-8.7	-7.5
ST CLAIR	Alabama	1115	1	1	227.1	-4.9	10.1	47.4	21.4	29.5	29.0	4.5
FLOYD	Kentucky	21071	0	0	-31.0	-22.2	-13.8	35.9	-10.6	-2.6	-7.0	-6.4
FAYETTE	West Virginia	54019	0	1	-46.5	-25.1	-20.1	17.3	-17.1	-0.8	-3.3	-4.1
CLAY	Kentucky	21051	0	0	-10.8	-10.2	-10.9	23.1	-4.4	12.9	-11.1	-5.6
KNOX	Kentucky	21121	0	0	3.5	-16.9	-6.2	27.6	-1.9	7.1	0.2	-1.3
LINCOLN	West Virginia	54043	0	1	-6.2	-9.8	-6.7	25.2	-9.7	3.4	-1.8	-2.9
WHITLEY	Kentucky	21235	0	0	13.0	-19.2	-6.5	38.3	-0.2	7.6	-0.3	0.9
GREENBRIER	West Virginia	54025	0	0	-10.0	-12.3	-6.8	17.4	-7.9	-0.7	3.2	-0.6
Average					**7.3**	**-17.9**	**-7.6**	**28.8**	**-4.4**	**4.4**	**0.8**	**-2.8**
Std Dev					**79.4**	**8.5**	**10.0**	**9.4**	**10.3**	**10.9**	**11.4**	**3.7**
Ten Worst Performing Mining-Intensive Counties												
MARION	Tennessee	47115	1	1	38.5	2.5	-2.2	18.7	1.8	11.7	1.5	0.8
KANAWHA	West Virginia	54039	1	1	-22.5	5.5	-9.3	0.8	-10.3	-3.6	-3.7	-3.6
CARBON	Pennsylvania	42025	1	1	11.1	-8.1	-4.4	5.4	6.7	3.4	10.7	-1.8
LACKAWANNA	Pennsylvania	42069	1	1	-17.8	-8.9	-0.2	-2.6	-3.9	-2.6	0.5	-1.4
SOMERSET	Pennsylvania	42111	1	0	-8.4	-5.3	-1.8	6.8	-3.7	2.3	-3.0	-3.5
BELMONT	Ohio	39013	1	1	-22.0	-4.4	-3.5	2.0	-13.9	-1.2	-0.1	-2.4
WALKER	Alabama	1127	1	1	1.1	-15.0	3.8	22.1	-1.4	4.5	-5.2	-3.8
CAMBRIA	Pennsylvania	42021	1	1	-35.8	-3.0	-8.1	-1.9	-11.0	-6.4	-6.1	-6.1
JEFFERSON	Ohio	39081	1	1	-30.7	2.8	-3.0	-4.8	-12.3	-8.0	-6.2	-3.5
WAYNE	West Virginia	54099	1	1	5.2	0.7	-3.6	22.5	-9.5	3.0	-1.5	-3.7
Average					**-8.1**	**-3.3**	**-3.2**	**6.9**	**-5.8**	**0.3**	**-1.3**	**-2.9**
Std Dev					**22.5**	**6.3**	**3.7**	**10.4**	**6.8**	**5.9**	**5.0**	**1.8**

(continued)

County	State	FIPS	MSA 73	MSA 13	%Δp 5018	%Δp 5060	%Δp 6070	%Δp 7080	%Δp 8090	%Δp 9000	%Δp 0010	%Δp 1018
Average US Metropolitan (1973)					301.0	32.4	25.0	23.3	13.1	16.5	11.9	5.4
Std Dev					465.3	65.9	82.2	27.5	18.4	17.2	14.9	7.8
Average US Nonmetropolitan (1973)					72.6	0.4	1.1	15.6	2.0	9.6	3.5	-0.2
Std Dev					313.6	22.6	17.0	23.8	15.6	15.4	11.8	7.1
Average ARC Metropolitan (1973)					176.5	9.8	9.3	18.5	6.6	12.7	8.2	1.0
Std Dev (Based on all ARC metro counties)					438.7	15.7	14.9	23.3	20.5	21.7	15.9	7.2
Average ARC Nonmetropolitan (1973)					44.9	-4.9	0.8	17.5	1.5	10.5	4.5	-1.1
Std Dev (Based on all ARC nonmetro counties)					91.0	11.8	11.1	10.5	11.3	13.0	9.9	5.2

Sources: The 1973 and 2013 MSA categories are from the U.S. Census Bureau Historical MSA Classifications. Population data is from U.S. Census Bureau, Population Estimates.

Notes:

1. FIPS denotes the county code. MSA73 and MSA 2013 denote whether a county was considered a "metropolitan statistical area" based on the 1973 and 2013 MSA categories from the U.S. Census Bureau Historical MSA Classifications, respectively.

2. The individual categories are the four relatively successful coal-transition counties. The higher-, median-, and low-performing mining counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described in the text. The high-performing are the 10 highest residual cases, net of the successful coal-transition counties, representing "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residuals, reflecting median performing counties and underperforming mining counties.

3. The grey shading in the successful county grouping means it grew faster than the county's respective ARC average growth rate for metropolitan or nonmetro counties for the period. Grey cross-hatching means that the county's growth rate was between the U.S. and the ARC growth rate in period when the ARC's average rate exceeded *the U.S. average.*

Appendix E Table 2:

Successful and Selected Counties' Mining/Coal Employment Share 1950-2016

County	State	FIPS	MSA 73	MSA 13	MSH 50	MSH 60	MSH 70	MSH 80	MSH 90	MSH 00	MSH 10	MSH 15	COAL 16
Successful Coal Transition Counties													
LAUREL	Kentucky	21125	0	0	5.8	1.8	0.9	9.9	2.8	0.8	3.2	0.8	0.8
SEQUATCHIE	Tennessee	47153	1	1	15.8	5.4	6.3	7.8	1.5	0.5	0.0	0.0	0.0
ATHENS	Ohio	39009	0	0	11.6	2.4	0.7	5.0	1.7	0.6	0.5	0.0	0.0
NOBLE	Ohio	39121	0	0	9.9	5.2	9.9	17.7	7.8	2.9	1.3	0.5	0.7
Average					**10.7**	**3.7**	**4.4**	**10.1**	**3.4**	**1.2**	**1.2**	**0.3**	**0.4**
Std Dev					**4.1**	**1.9**	**4.5**	**5.4**	**3.0**	**1.1**	**1.4**	**0.4**	**0.4**
Ten Best Performing Mining-Intensive Counties													
GREENE	Pennsylvania	42059	0	0	37.5	46.0	17.2	22.9	9.6	6.1	18.2	6.3	6.6
PERRY	Ohio	39127	0	1	18.2	8.1	6.8	12.6	5.1	1.6	0.5	1.9	5.0
FAYETTE	Pennsylvania	42051	0	1	26.9	4.1	7.7	9.2	2.9	2.1	0.3	0.0	0.0
PICKENS	Georgia	13227	0	1	11.3	0.0	3.0	6.5	1.6	0.7	0.0	0.0	0.0
SHELBY	Alabama	1117	1	1	10.5	3.0	1.5	2.7	0.6	0.5	0.2	0.1	0.2
MONONGALIA	West Virginia	54061	0	1	25.4	14.0	8.7	9.7	5.5	1.9	0.8	1.0	0.9
CUMBERLAND	Tennessee	47035	0	0	11.1	4.8	2.5	5.2	1.4	1.1	0.0	0.0	0.0
CLEARFIELD	Pennsylvania	42033	0	0	21.4	10.2	6.5	10.1	5.3	1.7	1.1	1.2	1.4
INDIANA	Pennsylvania	42063	0	0	27.6	13.3	7.7	16.1	8.1	2.5	1.3	0.7	0.9
SCHUYLKILL	Pennsylvania	42107	0	0	25.8	11.1	3.7	4.4	1.7	0.9	0.6	0.5	0.7
Average					**21.6**	**11.5**	**6.5**	**10.0**	**4.2**	**1.9**	**2.3**	**1.2**	**1.6**
Std Dev					**8.8**	**13.0**	**4.5**	**6.1**	**3.1**	**1.6**	**5.6**	**1.9**	**2.3**
Ten Median Performing Mining-Intensive Counties													
LEE	Virginia	51105	0	0	29.7	6.5	10.0	20.6	9.7	5.3	0.0	0.0	0.1
LESLIE	Kentucky	21131	0	0	33.4	75.4	25.8	32.4	29.3	13.2	2.0	1.9	3.3
ST CLAIR	Alabama	1115	1	1	11.2	0.0	0.3	2.6	0.3	0.1	0.0	0.0	0.0
FLOYD	Kentucky	21071	0	0	49.4	35.6	18.3	24.9	15.6	8.5	2.2	3.6	3.8
FAYETTE	West Virginia	54019	0	1	49.5	23.1	20.3	18.3	7.0	4.1	1.8	3.8	5.6
CLAY	Kentucky	21051	0	0	22.4	26.6	14.1	23.1	12.7	4.3	0.9	0.0	0.1
KNOX	Kentucky	21121	0	0	18.5	2.6	3.1	10.4	5.7	1.4	0.9	0.4	0.5
LINCOLN	West Virginia	54043	0	1	22.0	6.6	8.2	13.2	8.3	4.2	0.4	0.0	0.0
WHITLEY	Kentucky	21235	0	0	13.8	0.0	3.2	9.5	4.5	1.4	0.7	1.1	1.2
GREENBRIER	West Virginia	54025	0	0	19.2	8.3	7.8	9.7	3.9	1.3	0.0	1.6	1.6
Average					**26.9**	**18.5**	**11.1**	**16.5**	**9.7**	**4.4**	**0.9**	**1.2**	**1.6**
Std Dev					**13.6**	**23.4**	**8.3**	**9.0**	**8.2**	**4.0**	**0.8**	**1.5**	**2.0**
Ten Worst Performing Mining-Intensive Counties													
MARION	Tennessee	47115	1	1	13.6	8.4	2.8	4.9	1.4	0.3	0.0	0.0	0.0
KANAWHA	West Virginia	54039	1	1	10.4	5.2	4.4	5.0	2.0	1.3	1.3	1.1	0.9
CARBON	Pennsylvania	42025	1	1	18.4	2.6	1.5	2.7	0.9	0.5	0.0	0.0	0.0
LACKAWANNA	Pennsylvania	42069	1	1	12.4	4.0	0.7	1.0	0.2	0.1	0.0	0.0	0.0
SOMERSET	Pennsylvania	42111	1	0	26.6	6.9	4.7	12.0	3.2	1.6	2.8	1.1	1.5
BELMONT	Ohio	39013	1	1	17.2	6.7	10.9	14.4	4.6	2.6	2.5	1.7	2.1
WALKER	Alabama	1127	1	1	24.1	8.8	7.8	17.0	8.5	3.6	2.4	1.2	1.7
CAMBRIA	Pennsylvania	42021	1	1	19.9	9.9	5.8	8.4	3.6	0.8	0.1	0.1	0.1
JEFFERSON	Ohio	39081	1	1	8.5	2.8	3.0	3.8	1.5	0.7	0.3	0.4	0.6
WAYNE	West Virginia	54099	1	1	8.2	2.7	1.4	4.7	3.0	1.7	4.5	2.7	4.5
Average					**15.9**	**5.8**	**4.3**	**7.4**	**2.9**	**1.3**	**1.4**	**0.8**	**1.1**
Std Dev					**6.4**	**2.7**	**3.2**	**5.4**	**2.4**	**1.1**	**1.6**	**0.9**	**1.4**

County	State	FIPS	MSA 73	MSA 13	MSH 50	MSH 60	MSH 70	MSH 80	MSH 90	MSH 00	MSH 10	MSH 15	COAL 16
Average ARC Metropolitan (1973)					4.2	1.5	1.3	3.8	0.9	0.5	1.5	1.5	0.5
Sdt Dev (Based on all ARC metro counties)					6.3	2.4	2.0	3.2	1.3	0.8	1.4	1.3	2.0
Average ARC Nonmetropolitan (1973)					7.4	4.5	3.7	9.1	2.8	1.5	4.0	3.5	1.1
Std Dev (Based on all ARC nonmetro counties)					12.9	10.6	7.3	8.0	5.4	2.8	3.9	2.7	3.8

Sources: The 1973 and 2013 MSA categories are from the U.S. Census Bureau Historical MSA Classifications. 1950-2010 mining employment is derived from U.S. Census Bureau, decennial censuses. 2016 mining employment are from the five-year county average in the American Community Survey. *The 2016 coal mining share is derived using coal employment data from the U.S. Census Bureau,* County Business Patterns *along with estimates from The Upjohn Institute of Employment Research (see the text for details). The denominator is the civilian labor force from the U.S. Census Bureau decennial census, except for 2010 and 2016, which use the five year county average from the* American Community Survey.

Notes:
1. FIPS denotes the county code. MSA73 and MSA 2013 denote whether a county was considered a "metropolitan statistical area" based on the 1973 and 2013 MSA categories from the U.S. Census Bureau Historical MSA Classifications, respectively.
2. The individual categories are the four relatively successful coal-transition counties. The high-, median-, and low-performing mining counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models shown in Table 1. The high-performing mining-intensive counties are the 10 highest residual cases, net of the successful coal-transition counties, representing "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and lowest-10 residuals, reflecting median performing counties and underperforming mining counties.

Appendix E Table 3:

Successful and Selected Counties' Nominal Median Household Income 1950-2018

County	State	MI1950	MI1970	MI1980	MI1990	MI2000	MI2010	MI2018
Successful Coal Transition Counties								
LAUREL	Kentucky	1,260	6,088	11,961	18,584	27,015	36,835	39230
SEQUATCHIE	Tennessee	1,307	6,445	10,972	19,223	30,959	33,181	51,750
ATHENS	Ohio	2,112	8,617	11,839	19,169	27,322	33,836	37,778
NOBLE	Ohio	1,841	7,760	14,442	21,617	32,940	39,544	47,456
Average		**1,630**	**7,228**	**12,304**	**19,648**	**29,559**	**35,849**	**44,054**
Std Dev		**416**	**1,172**	**1,492**	**1,344**	**2,879**	**2,932**	**6,670**
Ten Best Performing Mining-Intensive Counties								
Average		**2,258**	**7,957**	**14,329**	**23,314**	**34,283**	**45,228**	**52,484**
Std Dev		**562**	**760**	**1,878**	**5,064**	**8,374**	**9,258**	**10,092**
Ten Median Performing Mining-Intensive Counties								
Average		**1,687**	**5,762**	**10,983**	**15,933**	**23,099**	**31,887**	**35,870**
Std Dev		**473**	**1,102**	**2,027**	**3,491**	**5,908**	**7,771**	**8,137**
Ten Worst Performing Mining-Intensive Counties								
Average		**2,543**	**8,618**	**15,205**	**22,078**	**31,282**	**42,076**	**46,488**
Std Dev		**656**	**1,148**	**1,762**	**2,030**	**2,475**	**4,052**	**4,748**
Average US counties		**3,300***	**8,605**	**14,313**	**23,979**	**34,832**	**44,973**	**50,792**
Sdt Dev		**-**	**1,936**	**3,413**	**6,612**	**9,457**	**12,525**	**14,456**
Average ARC Metropolitan (1973)		**2,368**	**8,912**	**15,648**	**25,727**	**36,988**	**46,238**	**52,066**
Std Dev (Based on all ARC metro counties)		**723**	**1,371**	**2,342**	**4,882**	**7,711**	**9,083**	**10,044**
Average ARC Nonmetropolitan (1973)		**1,710**	**7,149**	**12,471**	**20,353**	**29,989**	**37,332**	**42,667**
Std Dev (Based on all ARC nonmetro counties)		**659**	**1,405**	**2,211**	**4,099**	**5,567**	**6,953**	**7,886**

**the national average—i.e., not the national average across counties*

Sources: The 1973 and 2013 MSA categories are from the U.S. Census Bureau Historical MSA Classifications. 1950-2000 Median Household Income is from the U.S. Census Bureau, Decennial Census. 2010 and 2018 are from the American Community Survey five-year county estimates.

Notes:
In 1950, average family income is used due to data availability. The individual categories are the four relatively successful coal-transition counties from the text. The high-, median-, and low-performing mining-intensive counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described above. The high-performing are the 10 highest residual cases, net of the successful coal-transition counties, representing "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and lowest-10 residuals

Appendix E Table 4:

Successful and Selected Counties' Household Poverty Rate 1950-2018

County	State	PV1960	PV1970	PV1980	PV1990	PV2000	PV2010	PV2018
Successful Coal Transition Counties								
LAUREL	Kentucky	59.3	39.1	21.1	24.8	21.3	20.4	23.7
SEQUATCHIE	Tennessee	51.8	30.0	22.4	22.9	16.5	19.3	16.6
ATHENS	Ohio	32.4	29.1	21.6	28.7	27.4	32.2	30.6
NOBLE	Ohio	32.8	27.9	13.0	16.4	11.4	14.1	15.4
Average		**44.1**	**31.5**	**19.5**	**23.2**	**19.1**	**21.5**	**21.6**
Std Dev		**13.6**	**5.1**	**4.4**	**5.1**	**6.8**	**7.7**	**7.1**
Ten Best Performing Mining-Intensive Counties								
Average		**35.6**	**24.9**	**14.4**	**16.5**	**13.8**	**15.5**	**15.0**
Std Dev		**12.9**	**3.6**	**3.4**	**4.5**	**4.9**	**4.2**	**4.0**
Ten Median Performing Mining-Intensive Counties								
Average		**61.1**	**43.5**	**26.0**	**29.8**	**26.8**	**25.1**	**26.5**
Std Dev		**13.6**	**11.1**	**9.3**	**8.5**	**8.2**	**6.7**	**8.2**
Ten Worst Performing Mining-Intensive Counties								
Average		**29.8**	**21.0**	**12.3**	**15.7**	**13.9**	**15.6**	**16.4**
Std Dev		**11.3**	**5.8**	**4.1**	**3.8**	**2.9**	**3.1**	**3.2**
Average US counties		**34.3**	**24.1**	**15.8**	**16.7**	**15.1**	**17.1**	**16.4**
Sdt Dev		**16.5**	**9.8**	**7.3**	**8.0**	**8.9**	**8.2**	**8.2**
Average ARC Metropolitan (1973)		**30.4**	**20.6**	**12.7**	**13.6**	**12.1**	**14.9**	**14.5**
Std Dev (Based on all ARC metro counties)		**11.7**	**6.0**	**4.1**	**4.1**	**3.4**	**3.4**	**3.6**
Average ARC Nonmetropolitan (1973)		**45.9**	**30.4**	**19.1**	**20.3**	**17.3**	**20.1**	**19.1**
Std Dev (Based on all ARC nonmetro counties)		**15.5**	**10.3**	**7.4**	**8.1**	**6.6**	**5.7**	**5.7**

Sources: The 1973 and 2013 MSA categories are from the U.S. Census Bureau Historical MSA Classifications. The 1960 poverty rate is from the U.S. Department of Agriculture, Economic Research Service special tabulation. 1970, 1980, 1990, and 2000 poverty rates are from U.S. Census Bureau, Decennial Censuses. 2010 and 2018 are from the American Community Survey five-year county estimates.

Notes: The individual categories are the four successful coal-transition counties described above. The high-, median-, and low-performing mining counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models shown in Table 1. The high-performing are the 10 highest residual cases, net of the successful coal-transition counties, representing relatively "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residuals, reflecting median performing counties and underperforming mining counties.

Appendix E Table 5:

Successful and Selected Counties' Human Capital Share (% of population > 25yrs old)

County	State	CG 1950	CG 1980	CG 2000	CG 2018	SC 1950	SC 1980	SC 2000	SC 2018	HS 1950	HS 1980	HS 2000	HS 2018
Successful Coal Transition Counties													
LAUREL	Kentucky	2.2	6.7	10.6	13.4	4.9	8.5	18.4	27.1	6.3	27.3	34.8	40.6
SEQUATCHIE	Tennessee	1.5	5.7	10.2	14.6	2.1	5.0	18.0	28.8	8.3	28.5	38.5	39.2
ATHENS	Ohio	6.5	20.3	25.7	29.7	7.8	11.9	23.1	25.0	17.1	35.7	34.2	34.9
NOBLE	Ohio	2.6	5.9	8.1	10.3	4.2	7.1	22.7	25.8	18.7	50.3	47.8	49.1
Average		**3.2**	**9.7**	**13.7**	**17.0**	**4.8**	**8.1**	**20.5**	**26.7**	**12.6**	**35.5**	**38.9**	**40.9**
Std Dev		**1.9**	**6.2**	**7.0**	**7.5**	**2.0**	**2.5**	**2.4**	**1.4**	**5.4**	**9.2**	**5.4**	**5.2**
Ten Best Performing Mining-Intensive Counties													
Average		**3.6**	**10.5**	**16.8**	**22.5**	**4.4**	**8.7**	**19.6**	**25.6**	**14.1**	**37.0**	**41.4**	**39.8**
Std Dev		**1.7**	**5.5**	**9.3**	**10.1**	**1.3**	**2.2**	**3.5**	**3.4**	**4.7**	**7.9**	**9.4**	**9.6**
Ten Median Performing Mining-Intensive Counties													
Average		**2.1**	**7.2**	**9.7**	**13.4**	**3.8**	**7.4**	**17.6**	**25.2**	**7.3**	**25.4**	**33.3**	**38.2**
Std Dev		**0.9**	**1.5**	**2.5**	**3.9**	**1.2**	**1.8**	**3.9**	**3.7**	**3.0**	**6.1**	**4.1**	**3.8**
Ten Worst Performing Mining-Intensive Counties													
Average		**3.4**	**8.3**	**12.9**	**17.6**	**4.3**	**9.1**	**21.2**	**27.7**	**16.2**	**39.5**	**42.3**	**41.8**
Std Dev		**1.3**	**2.7**	**3.8**	**5.1**	**1.2**	**1.9**	**2.2**	**3.3**	**4.6**	**5.9**	**5.7**	**4.1**
Average US counties		**4.2**	**11.5**	**16.5**	**21.6**	**6.5**	**13.1**	**26.0**	**30.5**	**16.0**	**34.7**	**34.4**	**34.2**
Sdt Dev		**2.4**	**5.5**	**7.7**	**9.4**	**2.8**	**4.6**	**5.8**	**5.4**	**7.1**	**7.3**	**6.7**	**7.2**
Average ARC Metropolitan (1973)		**3.8**	**10.5**	**17.1**	**23.3**	**4.8**	**11.0**	**24.3**	**29.1**	**14.3**	**36.3**	**36.7**	**35.6**
Std Dev (Based on ARC metro counties)		**1.9**	**3.9**	**6.7**	**8.3**	**1.7**	**2.8**	**3.3**	**2.7**	**6.7**	**6.6**	**7.0**	**7.0**
Average ARC Nonmetropolitan		**3.0**	**8.2**	**11.9**	**16.5**	**4.4**	**8.6**	**20.0**	**26.5**	**10.5**	**30.9**	**37.5**	**39.4**
Std Dev (Based on ARC nonmetro counties)		**1.8**	**3.8**	**5.2**	**6.5**	**1.6**	**2.5**	**4.0**	**4.0**	**5.8**	**7.6**	**6.2**	**6.5**

Sources: Educational Attainment is Population data is from U.S. Census Bureau, Decennial Census of Population.

Notes:

1. CG: Four-year College Graduate; SC: Some college and/or Associate Degree; HS: High School Graduates share; measured as a share of the population 25 years and above.

2. The individual categories are the four relatively successful coal-transition counties from the text. The high-, median-, and low-performing mining-intensive counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described above. The high-performing mining-intensive counties are the 10 highest residual cases, net of the successful coal transition counties, representing relatively "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residuals.

Appendix E Table 6:

Successful and Selected Counties' Economic Structure (% of Total Employment)

County	State	AG 1950	AG 1980	AG 2000	AG 2018	MF 1950	MF 1980	MF 2000	MF 2018	SE 1950	SE 1980	SE 2000	SE 2018
Successful Coal Transition Counties													
LAUREL	Kentucky	42.1	20.1	8.8	5.3	6.0	25.0	17.0	10.8	39.9	23.4	18.3	18.4
SEQUATCHIE	Tennessee	28.9	17.2	11.0	7.8	16.8	20.6	25.5	8.9	29.0	25.8	27.2	36.1
ATHENS	Ohio	13.8	6.6	5.0	4.4	12.3	6.6	4.6	2.2	19.6	16.3	18.6	20.1
NOBLE	Ohio	44.6	36.6	25.9	23.3	10.1	16.7	24.3	4.5	42.3	30.6	27.7	35.5
Average		**32.3**	**20.1**	**12.7**	**10.2**	**11.3**	**17.2**	**17.9**	**6.6**	**32.7**	**24.0**	**23.0**	**27.5**
Std Dev		**12.3**	**10.8**	**7.9**	**7.7**	**3.9**	**6.8**	**8.3**	**3.4**	**9.1**	**5.2**	**4.5**	**8.3**
Ten Best Performing Mining-Intensive Counties													
Average		**13.0**	**8.8**	**6.1**	**4.5**	**23.0**	**18.8**	**12.4**	**7.5**	**17.1**	**18.3**	**21.7**	**24.9**
Std Dev		**9.7**	**5.7**	**4.3**	**3.6**	**9.6**	**8.6**	**5.6**	**4.1**	**6.7**	**5.5**	**5.7**	**7.6**
Ten Median Performing Mining-Intensive Counties													
Average		**25.7**	**15.8**	**9.3**	**7.1**	**28.0**	**9.7**	**7.6**	**4.9**	**24.0**	**22.5**	**22.8**	**25.5**
Std Dev		**12.3**	**14.6**	**8.4**	**7.0**	**14.4**	**6.3**	**4.1**	**4.3**	**8.9**	**6.3**	**7.7**	**4.2**
Ten Worst Performing Mining-Intensive Counties													
Average		**8.2**	**5.0**	**3.7**	**3.0**	**17.0**	**19.8**	**11.7**	**7.9**	**13.1**	**14.5**	**19.2**	**21.1**
Std Dev		**6.7**	**3.9**	**2.6**	**2.0**	**6.9**	**7.5**	**4.3**	**4.6**	**4.9**	**3.3**	**6.0**	**4.3**
Average US counties		**12.1***	**23.9**	**16.3**	**13.0**	**23.9***	**15.6**	**12.0**	**8.4**	**30.9**	**25.0**	**26.3**	**29.3**
Sdt Dev		-	**20.1**	**16.0**	**13.1**	-	**11.6**	**9.6**	**7.6**	**13.2**	**11.3**	**11.2**	**10.0**
Average ARC Metropolitan (1973)		**18.4**	**12.1**	**6.8**	**4.7**	**4.4**	**23.6**	**15.2**	**9.7**	**20.0**	**18.9**	**21.2**	**25.0**
Std Dev (Based on ARC metro counties)		**16.9**	**15.6**	**8.7**	**6.2**	**6.8**	**9.1**	**7.0**	**5.5**	**11.9**	**9.8**	**9.7**	**8.8**
Average ARC Nonmetropolitan		**32.9**	**21.9**	**14.1**	**11.1**	**7.7**	**23.6**	**17.4**	**11.2**	**30.6**	**24.2**	**25.8**	**28.4**
Std Dev (Based on ARC nonmetro counties)		**19.8**	**19.3**	**12.5**	**9.8**	**13.5**	**13.2**	**11.1**	**8.8**	**14.2**	**10.6**	**10.2**	**8.9**

**the national average—i.e., not the national average across counties.*

Sources: Industry composition and self-employment data is from U.S. Census Bureau, Decennial Census of Population.

Notes:
1. AG: Agricultural (including fishing, hunting) employment share; MF: Manufacture employment share; SE: Self-employment share, all measured by place of residence.

2. The individual categories are the four relatively successful coal-transition counties from the text. The high-, median-, and low-performing mining-intensive counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described above. The high-performing mining-intensive counties are the 10 highest residual cases, net of the successful coal transition counties, representing relatively "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residual.

Appendix E Table 7:

Successful and Selected Counties' Age Structure

County	State	U18 1950	U18 1980	U18 2000	U18 2018	O65 1950	O65 1980	O65 2000	O65 2018
Successful Coal Transition Counties									
LAUREL	Kentucky	46.7	32.4	25.4	23.2	7.2	10.8	11.5	15.7
SEQUATCHIE	Tennessee	47.7	31.7	24.6	21.3	6.6	10.7	12.3	19.5
ATHENS	Ohio	33.9	23.3	18.3	14.9	11.1	9.6	9.3	12.1
NOBLE	Ohio	35.3	30.4	22.6	18.4	14.1	14.9	13.1	25.9
Average		**40.9**	**29.5**	**22.7**	**19.5**	**9.8**	**11.5**	**11.5**	**18.3**
Std Dev		**6.4**	**3.6**	**2.7**	**3.2**	**3.0**	**2.0**	**1.4**	**5.1**
Ten Best Performing Mining-Intensive Counties									
Average		**38.7**	**28.2**	**22.7**	**19.8**	**8.2**	**12.4**	**15.0**	**18.8**
Std Dev		**4.4**	**2.9**	**2.7**	**2.3**	**1.4**	**2.4**	**3.8**	**4.6**
Ten Median Performing Mining-Intensive Counties									
Average		**48.1**	**32.3**	**24.1**	**21.8**	**5.8**	**11.4**	**13.4**	**17.6**
Std Dev		**4.2**	**2.6**	**1.6**	**1.6**	**1.1**	**2.1**	**2.2**	**2.2**
Ten Worst Performing Mining-Intensive Counties									
Average		**37.6**	**27.6**	**22.2**	**20.1**	**7.7**	**13.2**	**17.2**	**19.9**
Std Dev		**5.3**	**2.0**	**0.9**	**1.1**	**1.5**	**1.7**	**2.2**	**0.9**
Average US counties		**38.1**	**29.5**	**25.6**	**22.3**	**8.7**	**13.2**	**14.6**	**18.4**
Sdt Dev		**5.2**	**3.7**	**3.4**	**3.5**	**2.6**	**4.2**	**4.2**	**4.5**
Average ARC Metropolitan (1973)		**38.5**	**28.6**	**23.8**	**21.2**	**7.5**	**11.3**	**14.2**	**18.2**
Std Dev (Based on ARC metro counties)		**4.7**	**2.4**	**2.1**	**2.2**	**1.8**	**2.2**	**3.3**	**2.9**
Average ARC Nonmetropolitan		**41.8**	**29.5**	**23.8**	**20.8**	**8.0**	**12.6**	**14.6**	**19.3**
Std Dev (Based on ARC nonmetro counties)		**5.1**	**2.8**	**2.3**	**2.6**	**2.2**	**2.2**	**2.6**	**3.5**

Sources: Age structure is from U.S. Census Bureau, Decennial Census of Population.

Notes:
1. U18: Population share younger than 18 (in the case of 1950, younger than 20 and we use U20); O65: population share older than 65; measured as a share of the county's population.

2. The individual categories are the four relatively successful coal-transition counties from the text. The high-, median-, and low-performing mining-intensive counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described above. The high-performing mining-intensive counties are the 10 highest residual cases, net of the successful coal transition counties, representing relatively "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residuals.

Appendix E Table 8:

Successful and Selected Counties' Distance to Nearest MSA, Amenity Level, GINI index, Unemployment Rate and Racial Composition

County	State	DISTMSA	AMENITY	RUCODE	TOPO	GINI	UNEMP	WHITE
Successful Coal Transition Counties								
LAUREL	Kentucky	85.5	4.0	7	19	0.47	8.1	97.0
SEQUATCHIE	Tennessee	16.4	3.0	6	16	0.40	5.6	97.1
ATHENS	Ohio	20.7	3.0	4	18	0.51	7.7	90.6
NOBLE	Ohio	30.7	4.0	8	18	0.45	4.8	92.5
Average		**38.3**	**3.5**	**6.3**	**17.8**	**0.46**	**6.5**	**94.3**
Std Dev		**27.7**	**0.5**	**1.5**	**1.1**	**0.04**	**1.4**	**2.8**
Ten Best Performing Mining-Intensive Counties								
Average		**24.1**	**3.9**	**4.4**	**17.7**	**0.45**	**6.3**	**92.36**
Std Dev		**17.1**	**0.3**	**2.2**	**1.7**	**0.03**	**1.1**	**4.70**
Ten Median Performing Mining-Intensive Counties								
Average		**54.5**	**3.2**	**7.1**	**18.7**	**0.47**	**8.4**	**94.9**
Std Dev		**25.4**	**0.4**	**2.0**	**1.7**	**0.03**	**2.0**	**3.2**
Ten Worst Performing Mining-Intensive Counties								
Average		**7.7**	**3.5**	**2.8**	**17**	**0.45**	**6.6**	**93.2**
Std Dev		**8.1**	**0.5**	**1.2**	**1.8**	**0.02**	**1.2**	**2.6**
Average US counties		**48.7**	**3.5**	**5.5**	**8.9**	**0.45**	**6.1**	**82.6**
Sdt Dev		**50.3**	**1**	**2.7**	**6.6**	**0.04**	**3.6**	**17.1**
Average ARC Metropolitan (1973)		**9.0**	**3.6**	**2.4**	**15.2**	**0.45**	**5.6**	**88.2**
Std Dev (Based on ARC metro counties)		**8.4**	**0.5**	**1.6**	**4.6**	**0.03**	**1.4**	**11.1**
Average ARC Nonmetropolitan		**39.6**	**3.5**	**6.5**	**15.5**	**0.45**	**6.9**	**90.2**
Std Dev (Based on ARC nonmetro counties)		**26.9**	**0.6**	**2.1**	**5.0**	**0.03**	**2.4**	**12.1**

Sources: DISTMSA is from author calculations; AMENITY RUCODE, TOPO are from USDA Economic Research Service; GINI, UNEMP, and WHITE are from the U.S. Department of Labor for the Unemployment Rates and U.S. Census Bureau, American Community Survey for the GINI and percent of the population that is White.

Notes:
1. DISTMA denotes distance in miles from the population weighted centroid of the county to the population-weighted centroid of the nearest metropolitan area. AMENITY index is a one to seven scale reflecting the county's level of natural amenities (seven is highest amenities). The amenity measure is calculated by the U.S. Department of Agriculture (USDA). RUC denotes the 2013 USDA rural-urban codes (RUC), expressed on a 1 to 9 scale, 1 being the most urban, 9 being the most rural. TOPO is the topography index expressed on a scale of 1 (flat) to 21 (most mountainous) used to calculate the USDA AMENITY measure. See the text for more details of variable definitions.

2. The individual categories are the four relatively successful coal-transition counties from the text. The high-, median-, and low-performing mining-intensive counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described above. The high-performing mining-intensive counties are the 10 highest residual cases, net of the successful coal transition counties, representing relatively "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residuals.

Appendix E Table 9:

Successful and Selected Counties' Population 1950-2018

County	State	MSA73	MSA13	Pop 1950	Pop 1960	Pop 1970	Pop 1980	Pop 1990	Pop 2000	Pop 2010	Pop 2018
Successful Coal Transition Counties											
LAUREL	Kentucky	0	0	25,797	24,901	27,386	38,982	43,438	52,715	58,891	60,180
SEQUATCHIE	Tennessee	1	1	5,685	5,915	6,331	8,605	8,863	11,370	14,173	14,730
ATHENS	Ohio	0	0	45,839	46,998	54,889	56,399	59,549	62,223	64,592	65,936
NOBLE	Ohio	0	0	11,750	10,982	10,428	11,310	11,336	14,058	14,643	14,443
Average				**22,268**	**22,199**	**24,759**	**28,824**	**30,797**	**35,092**	**38,075**	**38,822**
Std Dev				**17,829**	**18,378**	**22,058**	**22,943**	**24,808**	**26,152**	**27,428**	**28,084**
Ten Best Performing Mining-Intensive Counties											
Average				**74,682**	**68,234**	**66,445**	**74,906**	**76,117**	**84,166**	**90,711**	**92,092**
Std Dev				**68,156**	**58,958**	**53,088**	**51,844**	**47,397**	**48,998**	**54,874**	**57,600**
Ten Median Performing Mining-Intensive Counties											
Average				**36,150**	**29,206**	**26,244**	**33,640**	**32,051**	**33,953**	**35,258**	**34,757**
Std Dev				**19,368**	**14,056**	**10,734**	**13,035**	**12,196**	**14,962**	**19,738**	**20,967**
Ten Worst Performing Mining-Intensive Counties											
Average				**115,316**	**111,837**	**106,853**	**109,034**	**101,029**	**99,030**	**96,997**	**93,957**
Std Dev				**86,670**	**85,502**	**79,816**	**76,205**	**69,421**	**65,495**	**63,732**	**61,928**
Average US Metropolitan (1973)				**157,499**	**198,717**	**231,722**	**258,450**	**287,394**	**325,204**	**357,344**	**381,580**
Std Dev				**350,511**	**419,829**	**466,725**	**481,156**	**536,714**	**590,823**	**626,439**	**664,334**
Average US Nonmetropolitan (1973)				**204,867**	**21,048**	**21,887**	**26,683**	**28,373**	**31,982**	**34,818**	**35,911**
Std Dev				**18,127**	**19,952**	**22,032**	**44,037**	**52,317**	**61,409**	**70,074**	**76,911**
Average ARC Metropolitan (1973)				**104,267**	**113,650**	**118,781**	**127,917**	**130,733**	**141,819**	**153,334**	**158,528**
Std Dev (Based on all ARC metro counties)				**186,759**	**201,229**	**199,853**	**187,368**	**177,661**	**180,127**	**187,392**	**196,526**
Average ARC Nonmetropolitan (1973)				**29,273**	**28,342**	**28,698**	**32,893**	**33,192**	**36,204**	**38,194**	**38,182**
Std Dev (Based on all ARC nonmetro counties)				**26,055**	**25,839**	**26,083**	**28,280**	**28,218**	**30,192**	**32,543**	**33,435**

Sources: The 1973 and 2013 MSA categories are from the U.S. Census Bureau Historical MSA Classifications. Population data is from U.S. Census Bureau, Population Estimates.

Notes:
1. MSA73 and MSA 2013 denote whether a county was considered a "metropolitan statistical area" based on the 1973 and 2013 MSA categories from the U.S. Census Bureau Historical MSA Classifications, respectively. 2. The individual categories are the four relatively successful coal-transition counties from the text. The high-, median-, and low-performing mining-intensive counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described above.

2. The high-performing mining-intensive counties are the 10 highest residual cases, net of the successful coal transition counties, representing relatively "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residuals.

Appendix E Table 10:

Successful and Selected Counties' Social Capital Measures

County	State	SK 2014	ASSN 2014	PVOTE 2012	RESPN 2010	NCCS 2014
Successful Coal Transition Counties						
LAUREL	Kentucky	-1.8	0.7	0.5	0.8	154
SEQUATCHIE	Tennessee	-1.5	0.5	0.6	0.8	50
ATHENS	Ohio	-0.5	1.0	0.6	0.7	446
NOBLE	Ohio	-0.1	1.5	0.7	0.7	70
Average		**-1.0**	**0.9**	**0.6**	**0.7**	**180**
Std Dev		**0.7**	**0.4**	**0.0**	**0.0**	**158.5**
Ten Best Performing Mining-Intensive Counties						
Average		**-0.5**	**1.3**	**0.6**	**0.8**	**400.3**
Std Dev		**0.4**	**0.3**	**0.1**	**0.0**	**202.5**
Ten Median Performing Mining-Intensive Counties						
Average		**-1.5**	**0.9**	**0.5**	**0.7**	**119.0**
Std Dev		**0.6**	**0.3**	**0.1**	**0.1**	**74.3**
Ten Worst Performing Mining-Intensive Counties						
Average		**-0.3**	**1.5**	**0.6**	**0.7**	**476.0**
Std Dev		**0.8**	**0.4**	**0.1**	**0.1**	**372.8**
Average US Counties		**0.0**	**1.4**	**0.7**	**0.7**	**463.2**
Std Dev		**1.3**	**0.7**	**0.1**	**0.1**	**1,399**
Average ARC Metropolitan (1973)		**-0.5**	**1.2**	**0.6**	**0.8**	**724.5**
Std Dev (Based on all ARC metro counties)		**0.6**	**0.4**	**0.1**	**0.1**	**1,218**
Average ARC Nonmetropolitan (1973)		**-0.7**	**1.2**	**0.6**	**0.7**	**159.5**
Std Dev (Based on all ARC nonmetro counties)		**0.8**	**0.4**	**0.1**	**0.1**	**155.9**

Source: Data from Rupasingha et al. (2006)

Notes:

1. SK2014 is an overall measure of Social capital index; ASSN2014 is the total number of religious, civic, business, political, professional, labor, and recreational establishment divided by population per 1,000; PVOTE2012: Voter turnout in the 2012 election; RESPN2010 is the 2010 Census response rate; NCCS2014 is the number of non-profit organizations without including those with an international approach.

2. The individual categories are the four relatively successful coal-transition counties from the text. The high-, median-, and low-performing mining-intensive counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described above. The high-performing mining-intensive counties are the 10 highest residual cases, net of the successful coal transition counties, representing relatively "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residuals.

Appendix E Table 11:

Successful and Selected Counties' Government Capacity

County	State	FiscalAuto	RevenuePerCapita	ExpendPerCapita	FiscalStress
Successful Coal Transition Counties					
LAUREL	Kentucky	0.5	2,332.0	2,050.8	1.1
SEQUATCHIE	Tennessee	0.4	2,487.0	1,901.0	1.3
ATHENS	Ohio	0.5	3,599.6	3,639.5	1.0
NOBLE	Ohio	0.5	3,371.3	2,513.1	1.3
Average		**0.5**	**2,947.5**	**2526.1**	**1.2**
Std Dev		**0.0**	**546.8**	**681.2**	**0.1**
Ten Best Performing Mining-Intensive Counties					
Average		**0.5**	**3,105.8**	**2,874.8**	**1.1**
Std Dev		**0.1**	**559.1**	**487.0**	**0.1**
Ten Median Performing Mining-Intensive Counties					
Average		**0.4**	**2,735.2**	**2,669.2**	**1.0**
Std Dev		**0.1**	**390.9**	**468.7**	**0.1**
Ten Worst Performing Mining-Intensive Counties					
Average		**0.6**	**3,488.3**	**3,155.8**	**1.1**
Std Dev		**0.1**	**1,128.5**	**1,104.3**	**0.1**
Average US Counties		**0.6**	**4,649.0**	**4,108.0**	**1.1**
Std Dev		**1.4**	**2,817.9**	**2,328.6**	**0.3**
Average ARC Metropolitan (1973)		**0.6**	**3,707.7**	**3,292.4**	**1.1**
Std Dev (Based on all ARC metro counties)		**0.1**	**1,306.9**	**1,043.4**	**0.2**
Average ARC Nonmetropolitan (1973)		**0.5**	**3,364.8**	**3,012.7**	**1.1**
Std Dev (Based on all ARC nonmetro counties)		**0.1**	**1,075.4**	**986.5**	**0.2**

Source: U.S. Census Bureau, 2012 Census of Local Governments.

Notes:

1. The various FY 2012 measures for the local county fiscal variables are: FiscalAuto: Own-Source Revenue/ State & Federal Revenue ($); RevenuePerCapita: Local Revenue per Capita ($); ExpendPerCapita: General Expenditures per Capita ($); FiscalStress: Revenue/Expenditures ($).

2. The individual categories are the four relatively successful coal-transition counties from the text. The high-, median-, and low-performing mining-intensive counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described above. The high-performing mining-intensive counties are the 10 highest residual cases, net of the successful coal transition counties, representing relatively "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residuals.

Appendix E Table 12:

Successful and Selected Counties' Mortality Rates

County	State	LE 1980	LE 2014	AL 1980	AL 2014	DR 1980	DR 2014	SU 1980	SU 2014	MU 1980	MU 2014
Successful Coal Transition Counties											
LAUREL	Kentucky	73.8	75.5	1.3	1.1	0.6	20.2	13.9	17.7	11.1	5.8
SEQUATCHIE	Tennessee	73.2	75.9	2.5	3.0	0.8	14.4	13.2	18.7	11.8	5.9
ATHENS	Ohio	73.4	76.9	1.4	2.4	0.5	14.0	14.2	13.7	3.2	3.0
NOBLE	Ohio	74.8	81.1	0.9	2.0	0.3	6.6	12.8	13.1	3.2	3.5
Average		**73.8**	**77.3**	**1.5**	**2.1**	**0.5**	**13.8**	**13.5**	**15.8**	**7.3**	**4.6**
Std Dev		**0.6**	**2.2**	**0.6**	**0.7**	**0.2**	**4.8**	**0.5**	**2.4**	**4.1**	**1.3**
Ten Best Performing Mining-Intensive Counties											
Average		**73.4**	**77.9**	**1.4**	**1.9**	**0.6**	**13.3**	**14.9**	**16.6**	**5.2**	**3.7**
Std Dev		**0.9**	**1.0**	**0.6**	**0.4**	**0.3**	**3.7**	**2.0**	**2.6**	**2.6**	**1.1**
Ten Median Performing Mining-Intensive Counties											
Average		**72.3**	**73.5**	**2.2**	**2.3**	**0.7**	**30.6**	**15.4**	**20.3**	**13.1**	**7.2**
Std Dev		**0.4**	**1.6**	**0.5**	**0.8**	**0.2**	**9.8**	**2.3**	**2.2**	**5.2**	**1.4**
Ten Worst Performing Mining-Intensive Counties											
Average		**73.0**	**76.3**	**1.4**	**2.1**	**0.7**	**19.7**	**13.6**	**18.5**	**6.2**	**5.4**
Std Dev		**0.8**	**2.0**	**0.8**	**0.9**	**0.2**	**7.0**	**2.0**	**4.2**	**3.8**	**2.7**
Average US counties		**73.8**	**77.8**	**2.9**	**3.1**	**0.7**	**9.9**	**14.9**	**17.1**	**7.7**	**5.0**
Sdt Dev		**1.8**	**2.4**	**2.8**	**2.7**	**0.5**	**6.0**	**3.5**	**5.7**	**5.5**	**3.5**
Average ARC Metropolitan (1973)		**73.5**	**77.2**	**2.1**	**2.3**	**0.7**	**15.0**	**14.2**	**16.5**	**7.0**	**5.1**
Std Dev (Based on ARC metro counties)		**0.8**	**1.6**	**1.4**	**0.9**	**0.3**	**6.0**	**2.3**	**3.4**	**3.8**	**2.3**
Average ARC Nonmetropolitan		**73.2**	**76.0**	**2.4**	**2.5**	**0.7**	**16.9**	**15.1**	**18.6**	**8.3**	**5.7**
Std Dev (Based on ARC nonmetro counties)		**1.2**	**2.2**	**1.2**	**0.9**	**0.2**	**9.7**	**2.4**	**3.9**	**4.3**	**2.7**

Source: Institute for Health Metrics and Evaluation (IHME) as provided by Global Health Data Exchange, available at: http://ghdx.healthdata.org/record/ihmedata/united-states-mortality-rates-county-1980-2014.

Notes:

1. The variables are measured in 2014. LE: Life expectancy at birth; AL: Age-standardized mortality rate for both sexes combined (deaths per 100,000 population) from Alcohol use disorders; DR: Age-standardized mortality rate for both sexes combined (deaths per 100,000 population) from Drug-use disorders; SU: Age-standardized mortality rates for both sexes combined (deaths per 100,000 population) from Self-harm; MU: Age-standardized mortality rate for both sexes combined (deaths per 100,000 population) from Interpersonal violence.

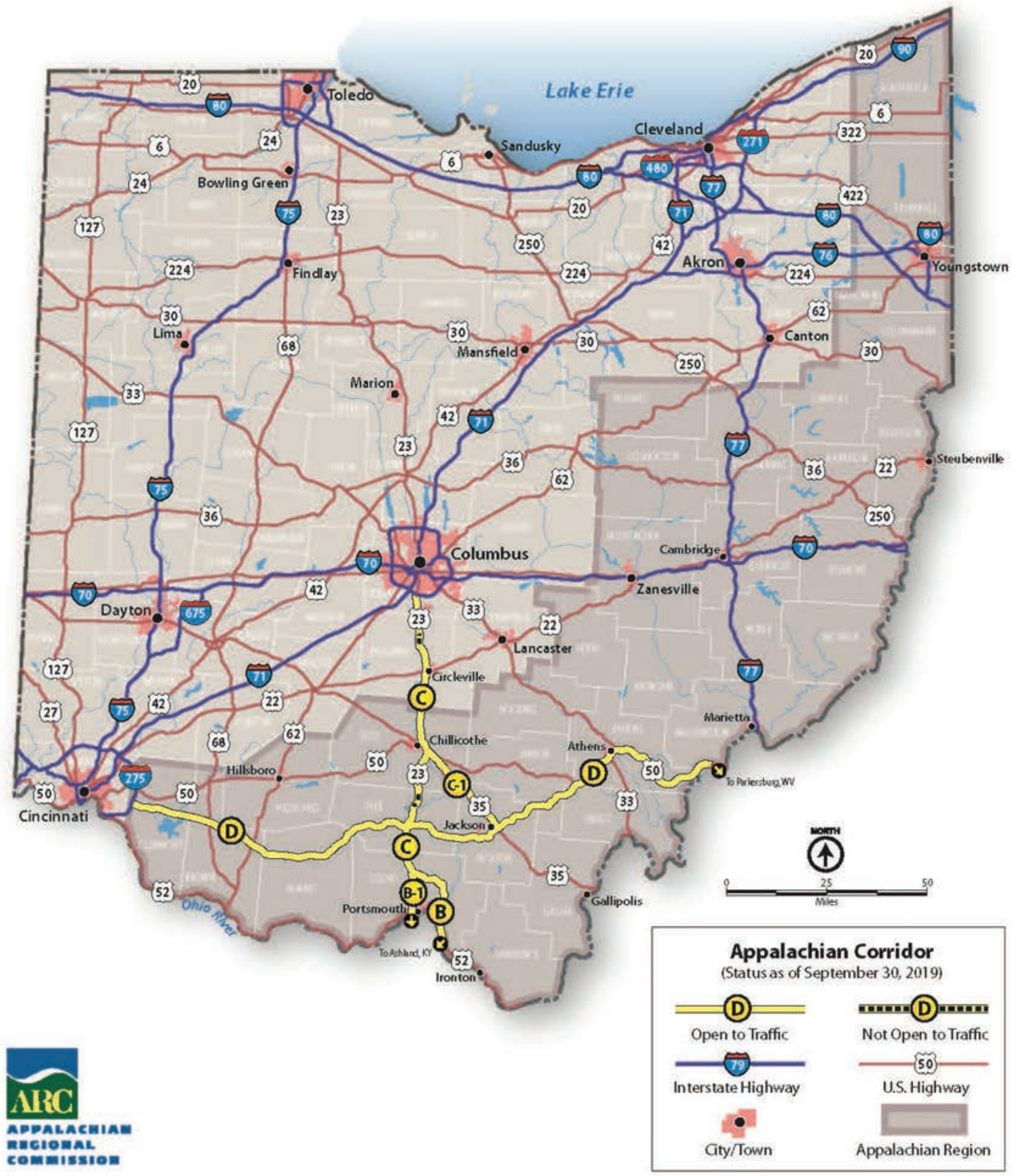
2. The individual categories are the four relatively successful coal-transition counties from the text. The high-, median-, and low-performing mining-intensive counties are from the regression ranking of the 99 residuals from the 1950-2018 population growth models described above. The high-performing mining-intensive counties are the 10 highest residual cases, net of the successful coal transition counties, representing relatively "over-performing" mining-intensive counties. Median- and Low-performing mining counties are the middle 10 counties from the 99 ranked residuals and the lowest-10 residuals.

APPENDIX F

Appalachian Development Highway System Maps

Appendix F Figure 1:

Appalachian Development Highway System Corridors in Ohio

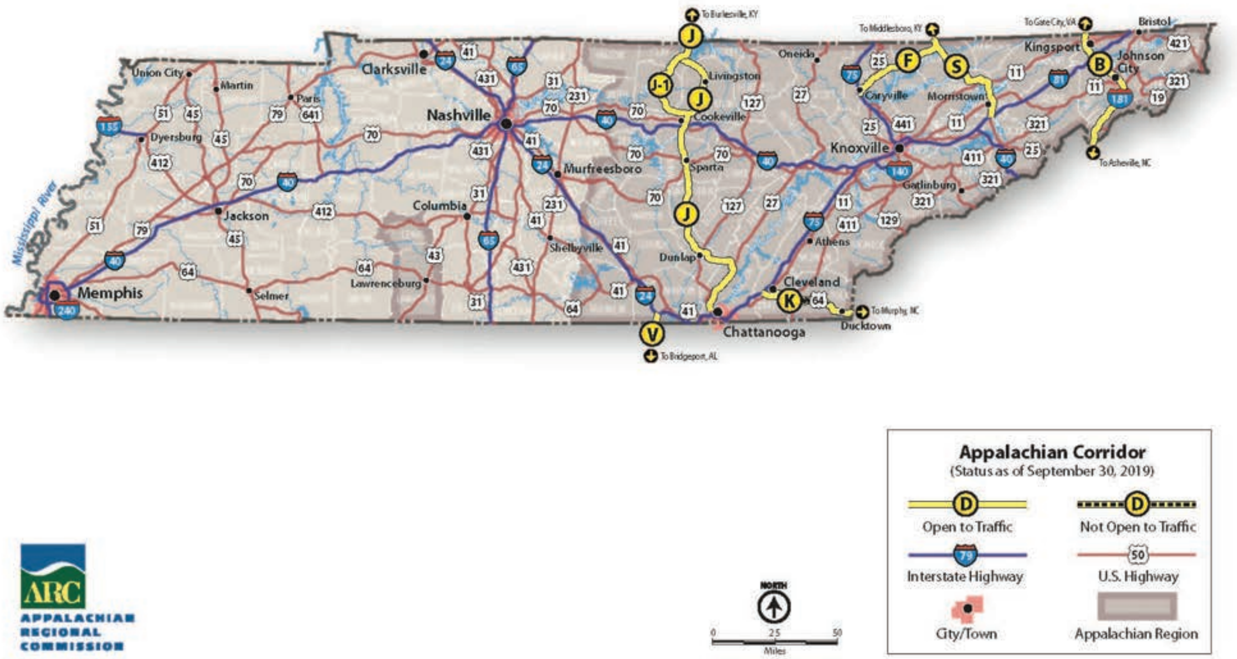


Appendix F Figure 2:

Appalachian Development Highway System in Kentucky

Appendix F Figure 3:

Appalachian Development Highway System in Tennessee



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