ENERGY TRANSITIONS IN COAL REGIONS: IS A JUST TRANSITION IN US APPALACHIA POSSIBLE?

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY:

As nations transition away from coal, regions and communities must adapt. By analyzing communities that have already experienced an energy transition, policymakers can better support other communities that face similar future challenges.

The purpose of this study is to assess factors that contribute to more successful community adaption after coal transition. A key goal is to address open questions about why some communities perform better than others and to inform best practices to promote a more "just transition" as market realities and policies to mitigate climate-change spur adaptation. The base for this research draws from Appalachia, a region significantly affected by coal sector decline.

Appalachia is mainly rural and spans the Appalachian Mountain range, nearby foothills, and related areas such as the Shenandoah Valley. The region has historically lagged in socioeconomic well-being. To address this issue, the Appalachian Regional Commission (ARC) was established in 1965. Today, the ARC covers parts of 13 states and contains 420 counties. In this report, we use the terms Appalachia, Appalachian region, and ARC interchangeably.

For many decades, Appalachia has been characterized by some of the lowest per-capita income levels and highest poverty rates of any U.S. region (Lobao, Partridge, Zhou, and Betz 2016). From the early 19th century, it was the primary producer of coal, historically producing more than 80% of U.S coal production. But Appalachia's reign as the dominant coal producer in terms of its national share of production began to wane in the late 1960s as production shifted west. By 1998, Appalachia's share of U.S. coal production was 41% and fell to 27% in 2018 (U.S. Energy Information Agency (EIA) 2019). While total U.S. coal production fell 6% over this 20-year period, Appalachian production fell by 41%. Meanwhile, Appalachia's national share of coal employment declined from 85% in 1954 to 57% in 2018. These changes along with the legacy of poverty make Appalachia's coal-country communities particularly vulnerable to the fortunes of the coal industry.

As past research is limited, questions remain in assessing communities that transitioned away from coal mining in the United States and in Appalachia in specific. Our research addresses these issues through an empirical analysis of Appalachian communities and by synthesizing the results of studies that document factors that promote community well-being and assist with transition.

This research focuses on four analytical questions:

1. Which Appalachian communities made a relatively more successful transition away from coal mining employment during the 20th century and up to today?

2. What were the resulting socioeconomic outcomes in these communities?

3. What factors mattered for Appalachian communities that recovered more successfully?

4. What are the lessons learned? What key factors contribute to revitalization in the

transition away from coal?

Our knowledge for answering these questions is limited in scope and detail. Although a number of studies exist on transition in the U.S. energy industry, much pertains to the nation as a whole and provides little information about how affected communities adapt. Meanwhile community studies largely focus on mining or resource extraction as an aggregate sector, rarely scrutinizing coal mining itself. Research that does exist on coal mining and community well-being tends to be case-study or limited in scope. Few studies assess the long-term consequences for communities that lost coal employment, and none to our knowledge assessed the temporal period needed for successful adjustment. For Appalachia, little is known about how communities have adapted overall as employment shifted away from coal in the post-Second World War period.

Our research aims to address these gaps through an analysis of quantitative data for the ARC's 420 counties, along with qualitative information on four "relatively successful" Appalachian coal mining communities that transitioned away from coal, as well as one successful post-mining Rocky Mountain community. These cases are compared to other mining-intensive ARC counties. The analysis spans the post-World War I period to the present. We also conduct an extensive a literature review which synthesizes findings from previous studies that examined extractive and other industries, and factors promoting positive community outcomes, especially in rural areas.

Compared to past studies, this research aims to produce more consistent and broad-based information about community outcomes in a largely rural and historically natural resource dependent region. We track communities over the long-term and document the degree of recovery. We further identify policy guidance stemming from the analyses.

In this executive summary, we provide an overview of the research findings elaborated in the body of this report.

- First, we summarize the results of the literature review and identify the factors that analysts see as significant determinants of well-being in small, rural and extractive communities, factors that should likewise lead to better outcomes for formerly coal intensive communities.

- Then we turn to questions one and two above. We identify communities that were more relatively more successful in transitioning beyond coal and the resulting socioeconomic outcomes. As explained more fully in this report, in analyzing "communities" we generally employ counties as the unit of analysis, also the unit used by the ARC to classify the region's communities. To identify coal transition, we focus on changes in coal mining employment and whether and when the community rebounded in population growth and the resulting socioeconomic well-being outcomes.

- The third section documents the factors that help to explain why some Appalachian communities have fared better than others. Here we draw from the quantitative analysis, information from the community cases, and the literature review findings to identify the barriers and facilitators of more successful coping with transition.

- In the fourth section, we summarize the policy implications of our research.
- Finally, we provide an introduction to the organization of the full report.

Identifying Factors Promoting Community Well-being: Literature Review Findings

We evaluated a range of studies to identify factors that potentially support community revitalization in the wake of coal transition. We summarize the conclusions of this large and disparate literature by dividing it into: studies focused on general factors that drive prosperity and poverty, particularly for rural and small U.S. communities; and targeted studies of communities experiencing natural resource, energy, and other industry transitions.

- Based on the general literature, four sets of factors that should assist in community revitalization are identified:

    1. Geographic attributes such as urban-rural location, distance from metropolitan centers, and degree of urbanization including population size
    2. Local economic structure or the quantity, quality, and industry mix of local employment.
    3. Sociodemographic factors such as education, age, race/ethnicity, and family structure that reflect residents' structural vulnerability
    4. Local institutional factors such as local governmental capacity and social capital.

The first three sets of factors are structural determinants commonly found to be associated with community well-being. For example, community socioeconomic well-being (e.g. lower poverty and higher income) has been higher historically in metropolitan counties and rural counties closer to metropolitan centers. Local well-being is also linked to "better-quality" employment sectors such as higher-wage services (e.g. producer services) and in the past, manufacturing. Communities with smaller shares of structurally vulnerable populations such those having higher educational attainment and fewer single-parent households tend to have less poverty and higher income. In addition, we denote a fourth less studied determinant: local institutional factors such as local governmental capacity and social capital that can enhance community resilience and prosperity. It is expected that coal communities having more favorable structural attributes and institutional capacity are likely to fare better in transitioning from the industry.

Turning to natural resource dependent communities, researchers often point to the natural resource curse and related frameworks to explain why these areas fare poorly over the long-run. They note that extractive industries give rise to self-reinforcing development paths that include displacement of other industries, less diverse local economies, underinvestment in education and lower human capital. These issues along with the remote rural location of many extractive communities suggest that the path toward revitalization is likely to be long and challenging.

- Targeted studies centered communities experiencing natural resource and other transitions likewise identify similar structural and institutional factors for coping with transition. Structural factors particularly important for extractive communities include: proximity to cities; the degree to which employment opportunities outside the extractive sector are available; and population vulnerability such as low educational attainment and an aging workforce. With regard to institutional factors, extractive communities often face limited local governmental capacity such as limited administrative leadership and staff capacity, small or inadequate budgets, lack of fiscal autonomy. External ties to state or regional actors are often weak.

- In addition to structural and institutional factors, targeted studies identify other factors that facilitate adaptation. These include: the quality of the local environment and presence of natural resource amenities; the degree of community attachment to a natural resource-based culture; and whether the costs of transition are borne evenly by local social groups. In terms of past policies and programs, researchers often point to shortcomings. Federal policy directed to rural and/or coal and other natural resource-dependent communities is long noted to be insufficiently funded, poorly targeted, and lacking in broad-based, sustained impact. With regard to various locally implemented economic development programs, benefits appear modest, successful models are difficult to replicate, and outcomes are difficult to evaluate.

In sum, based on past studies, coal communities characterized by more favorable structural conditions such as geography, economic structure, a smaller vulnerable population, along with greater institutional capacity are likely to cope better in transitioning from the industry.

Appalachian Communities that Made a Relatively More Successful Transition

The coal industry began its decline first in north Appalachia (Ohio and Pennsylvania) after World War I with central Appalachia following after World War II. While boom and bust periods occurred subsequently, the overall trajectory continued downward. In 1950, the top one-sixth of ARC counties had over 41% of their total share of employment in coal mining with this share dropping to under 17.5% by 2016. By 2017, coal employment even in the three most coal-intensive ARC states stood at 14,000 in WV, 6,500 in KY, and 5,400 in PA.

Identifying "successful" coal-transition counties

To select counties that "successfully" transitioned from coal, we followed a protocol outlined in the report. Briefly, the county had to manifest some former dependence upon coal employment (relative to other ARC counties), a threshold initially set at having a minimum of 8% of its total labor force in coal mining in 1950 and 4% in 1980. Of the 420 ARC counties, 99 met these criteria in 1950 and another 123 in 1980, yielding 222 candidate coal intensive counties. We select population growth as the metric to base success, the most common metric used to determine regional success in U.S. regional studies. Past studies find that population growth is negatively related to coal mining employment (Betz et al. 2015). Population growth succinctly captures other socioeconomic metrics such as per-capita income, poverty rates, and household income growth because people in- and out-migrate based on such socioeconomic conditions.

We use regression analysis to identify which counties over- or underperformed in terms of population growth given the county's initial endowments. A successful transition should be one in which the location overachieved in terms of initial conditions. We then use regression analysis with the percent change in population between period *t* and *period t+1* serving as dependent variable. Independent (*t*) variables include the share of mining employment, location, and population. The regression analyses were conducted multiple different time periods dating back to 1950 and the residuals analyzed to determine over and underperforming counties.

- Fewer than 15% of mining-intensive ARC counties (32 out of 222) grew faster than their corresponding 1950-2018 ARC average population growth-- *indicating that coal employment severely limits future population growth and that the pool of any potentially "successful-transition" candidates is small.*

From this pool of 32 potential candidate counties, we eliminate counties that had become part of metro areas, those where coal mining had not declined to be a small share (under 2%) of county employment and/or those that had still largely not transitioned away from coal mining.

- Out of the 32 mining counties that experienced growth, only four met the criteria for "successful coal transition counties":

    1. Sequatchie County, in southeastern Tennessee (transition period mid-1980s-1990s)
    2. Laurel County, in southeastern Kentucky (transition period late-1980s-1990s)
    3. Athens County, in southeastern Ohio (transition period 1970-1980)
    4. Noble County, in southeastern Ohio (transition period 1990-2000)

Other outcome measures for coal transition counties

We gauge other outcome indicators (in addition to population growth) that are associated with better socioeconomic outcomes and how the four counties compare to other mining-intensive counties. We compare the four counties to a range of other mining-intensive communities in terms to appraise what "success" actually entails in Appalachian context. The four counties are compared to 10 highest-, 10 median-, and 10 poorest-performing Appalachian mining counties. (The comparison counties were selected from the ranking of the residuals (error terms) from the 1950-2018 population growth models for the 99 mining counties noted above.)

- Overall, the four successful coal transition counties are doing better than most over-performing mining-intensive locations in population growth since 1990 and they are growing much faster than those in the middle or at the bottom.

- Yet median income and poverty rates in the four counties show less favorable outcomes compared to highest-performing mining-intensive locations and are closer to the median-performing mining counties.

- For comparison, we then initiated a similar process used to identify the four ARC "success" cases examining one case from the Rocky Mountain region. Specifically, we considered the historically mining-intensive states of Colorado and Nevada. Generally, their mining-intensive counties in 1950 performed better than those in the ARC region, but their coal producing counties also seemed to lag. We selected rural Ouray County, Colorado, a historic gold mining location in which mining had all but ceased by 1990. Ouray County seems to benefit from its spectacular mountain scenery and good road access that attract tourists and amenity migration.

Ouray County today only has about 5,000 residents, which is consistent with the general pattern we find for the four ARC "success" cases—i.e., urbanization is not a necessary factor for mining regions to successfully transition. Overall, Ouray County generally struggled in the 1890-1970 period, with its population declining approximately 74%. Yet, between 1970 and 2019, its population increased by about 220%.

Factors Explaining Why the Four Appalachian Counties Fared Better than Others

To examine why the four Appalachian counties were able to gain greater ground than others, we conducted a quantitative as well as qualitative analysis. Both analyses focused on the role of four key factors identified above that include geography, economic structure, sociodemographic characteristics, and institutional characteristics with the qualitative analysis allowing for additional elaboration.

The quantitative analysis compared the four relatively successful coal transition Appalachian counties to the 10 highest-, 10 median-, and 10 poorest-performing Appalachian mining counties using a range of variables measuring geography, economic structure, and sociodemographic and institutional factors. Based on this analysis, we found no clear patterns that indicate why the four cases relatively succeeded in their transition process. For example, proximity to urban centers, educational attainment, age structure, social capital and local governmental indicators were not markedly different when the four cases were compared to other counties. There were some exceptions, however, where the four cases displayed slight advantages which include higher initial shares of the self-employed, a higher percent of workers employed in manufacturing during the transition process, and somewhat better mortality rates.

In the qualitative analysis, we collected information from key informant interviews, electronic resources, and secondary sources to identify factors that explain why the four Appalachian coal transition counties had performed relatively better. As noted, we focus on the role of structural and institutional factors and other factors specific to each case. For comparison, we also included the characteristics of rural Ouray County, Colorado. The following are our findings.

- Each county is characterized by a unique configuration of factors that have influenced their growth with few clear, cross-cutting determinants.

- Structural and institutional factors denoted earlier (distance/rural location, non-mining economy, local governmental capacity, and social capital networks) play some role across the cases. However, the degree of importance of each of these factors varies and collectively they are not clear determinants of better future performance in each county.

- Highway infrastructure in place around the time of transition has been important to subsequent county performance. All four Appalachian counties contain major highways and two have federal interstates, which has spurred their growth. Ouray County, Colorado likewise contains a federal highway. Two counties became bedroom communities (Sequatchie for the city of Chattanooga and Noble for neighboring counties) and two (Athens and Laurel) grew into regional hubs for surrounding areas. We caution that historically, many coal mining intensive ARC counties also had significant investments in roads and other public infrastructure—suggesting that public investments may be necessary but are not sufficient for ultimate success.

- All the counties possess natural amenities (such as national forests, rivers, and scenery) that create opportunities for recreation and tourism and increase the desirability of the county as a place to reside.

- Public-sector development promoted growth in three counties. Athens contains a major regional research university system. Noble County relied on a state prison development in 1996. Laurel County received significant highway investment and a dam was constructed that provides low-cost hydroelectricity and outdoor recreation opportunities.

- Tourism, beyond natural amenities, plays a broad role in two counties (Athens and Sequatchie), which have worked to become regional destinations for festivals and/or the arts. Tourism is highly important in the case of Ouray, the Colorado county.

- Only one county (Laurel) has a strong and diverse industrial base composed of durable and nondurable manufacturing.

- Local governmental capacity with regard to administrative leadership to promote community development varies across the counties. Athens has a history of active engagement in economic development, local arts and cultural programs, social service provision and public-private and cross-county collaborations. The county is particularly active in grant-seeking from government and nonprofit sources. Sequatchie and Laurel local governments have long been active in economic development focused on external business attraction and investment. Noble County seems the least active with informants noting only periodic engagement in economic development and few social services.

- Social capital networks in terms of bonding (internal) and bridging (external) capital appear high only in Athens County. Their university linkages, public-private partnerships, a willingness to invest internally, along with external linkages to higher-level governments were noted.

- Among the four Appalachian counties, Athens appears to be the only one that experienced a cultural shift facilitating transition. A key informant noted that partly owning to the university and the diverse population it draws, relative to other Appalachian communities, there is greater appreciation of the arts and local culture, the promotion of more environmentally sustainable practices, and trying to remedy negative environmental impacts of coal.

- In terms of policy, all four Appalachian counties have benefited from the ARC. All are a part of multi-county groups of neighboring counties established by the ARC which provide access to funding opportunities for group projects. Athens has been especially active in securing POWER grants, a congressionally-funded initiative administered by the ARC that targets communities affected by coal mining job losses. All four counties have benefitted from the ARC's Appalachian Development Highway System. However, as noted above, less-successful counties have also received such state and federal investments, making it difficult to assess what is *sufficient* for eventual economic success.

Summary: Policy Guidance for Successful Coal Transitions

Based on the literature review of best practice development and the qualitative and quantitative analysis, we believe there are several policy guidelines that can generally inform the fastest and most just transition from coal mining. The following summarizes these guidelines:

1. From the coal miners' perspective, they possess a property right over their job and it is the government that is taking **their** job. If governments want to reduce opposition to transitioning from coal, it needs to consider a "buyout" of coal miners in order for miners to confidently believe they will be made whole—much akin to how large corporations buyout senior management. Miners' view of having a "property right" underlies their antagonism to using less-generous standard income support programs.

2. Generous training and education programs should also be provided to affected coal-mining workers.

3. Higher-level governments should consider back-filling lost tax revenues for coal-country local governments. After a sufficient time period, such subsidies should cease as they would become increasingly distortionary over time.

4. Coal communities are highly disadvantaged economically due to many factors. The environmental damage caused by the legacy of mining and manufacturing processing industries associated with mining will deter foot-loose high-skilled workers and entrepreneurs from locating in coal country. Given these disadvantages, it is very difficult and very expensive to revitalize local coal-country economies.

   Since good jobs will be much more difficult to create in coal country, many coal country workers will likely need to relocate to good jobs. Migration assistance is then necessary to effectively support households who wish to relocate to more prosperous communities.

5. Government along with the remnants of the coal industry would be mainly responsible for environmental clean-up. Sustainable economic development of the local communities requires a clean environment. Environmental cleanup would also be a source of employment for many displaced workers.

6. The general best-practice local economic development strategy is well-known: (1) diversify the local economy; (2) take advantage of the natural beauty or other natural amenities for tourism and related businesses, attracting part-year residents, and attracting new residents who can "telecommute" from anywhere, and (3) promote small business and new-firm development (Partridge and Olfert, 2011; Tsvetkova et al., 2019). In particular, the promotion of local entrepreneurship is critical.

7. In the near term, declining coal-country businesses need financial support to survive hard times. A policy of providing grants and bridge loans to struggling businesses would cushion the blow, allowing local businesses breathing room until the local economy recovers. Such aid should not be permanent because of distortionary effects and moral hazard effects.

8. There are typically a myriad of government programs in support of lagging coal regions. A capable higher-level agency would help facilitate economic transition by coordinating these efforts across differing local economic development agencies, nonprofits (e.g., Chambers of Commerce), and numerous local governmental authorities that especially exist in decentralized countries such as the United States. The ARC provides a good example because of its Local Development Agencies (LDAs). The LDAs are multiple-county economic development regions that coordinate regional development by bringing all of the relevant players to the table. LDAs serve as brokers that help initiate or support multi-actor projects by coordinating the parties and providing seed money to get projects off the ground. A robust higher-level development agency can also provide much needed governmental capacity for sparsely populated counties, which often lack basic skills for functions such as grant writing.

Organization of this Report

- After an introductory Section 1, Section 2 summarizes the literature review and identifies factors that analysts see as potentially key determinants of well-being in small, rural, and extractive communities.

- Section 3 presents long-term coal mining trends for the U.S. and the ARC region since World War I. Several key historic trends shape the current Appalachian coal mining situation. One is rapid labor-saving productivity growth in coal mining since 1919 has primarily led to falling coal mining employment. Between 1919 and 2017, short-tons of coal produced per coal miner has risen by over 21 fold—rising from 720 tons to 15,367 (see Section 3 for sources). Between 1923 and 2019, U.S. coal mining employment fell 94%, or over 800,000 mining jobs. Beginning in the mid-1960s, the second big event that adversely affected ARC coal mining was the shift of U.S. coal mining from Appalachia to the Northern Great Plains (NGP) due to vastly higher productivity in NGP mines and NGP coal having lower Sulphur dioxide content that was increasingly preferred due to air quality regulations.

  Third, a realignment of coal mining from Northern Appalachia—Pennsylvania and

Ohio—to Central Appalachia, primarily Kentucky and West Virginia. Between 1919 and 2017, Pennsylvania and Ohio each lost 98% of their coal mining jobs, while Kentucky and West Virginia lost a "mere" 85%. Since 2006, coal has faced a growing threat due to rapidly falling costs of natural gas caused by new shale-drilling technologies. Going forward to 2050, continued pressures due to environmental regulations, ongoing coal mining productivity growth, and increasing competitiveness of natural gas and alternative energies means that coal mining's employment footprint will be almost eliminated.

- Section 4 turns to questions one and two above. This section is mainly methodological and can be skipped for those uninterested in the empirical methodology. We identify four ARC communities that were "relatively successful" in transitioning beyond coal. In analyzing "communities" we employ counties as the unit of analysis, which is also used by the ARC to classify the region's communities. To identify coal transition, we focus on changes in coal mining employment and whether and when the community rebounded in population growth. We show why population growth is the theoretically correct measure to assess long-term well-being for U.S. counties.

- To be considered a "relatively successful" coal-transition county, the following criteria had to be met:

  1. The county had to be coal mining intensive in either 1950, 1980, 1990, and 2000.

  2. The county had to have a *subsequent period* in which coal mining was an insignificant part of the local economy—i.e., the county transitioned away from coal mining.

  3. For population growth, the county had to relatively "overachieved" using regression analysis in one of the following periods: 1950-2018, 1980-2018, 1990-2018, 2000-2018.

  4. The county's population growth had to exceed the ARC average in at least one decade.

  The analysis identifies 4 success counties out of approximately 222 ARC counties that are identified as mining dependent during some period. With only 4 success cases out of 420 ARC counties, the findings suggest that it is very difficult to successfully transition away from coal, and for the ARC region, mining-intensive counties appear to have suffered from the *natural resource curse*.

  Section 4 also discusses the relative size of coal-mining's impacts on national and local employment through input-output effects and local expenditures of employed workers who are supported by coal mining. This discussion indicates that nationally, coal mining's impact through input-output linkages is rather minuscule due to contemporary coal mining's relatively low employment, the relatively small size of the sectors that produce mining equipment, and any losses in coal-fired power plants would be offset by gains using alternative energies. For coal-mining intensive counties, the local spillovers are likewise relatively modest except for the very most coal-intensive counties.

- Section 5 documents the factors that help explain why some Appalachian communities fared better. Here we draw from the quantitative analysis, information from the community cases, and the literature review to identify barriers and facilitators of a more successful transition. Regarding successful coal-transition counties, the quantitative analysis does not point to many factors that explain the relative success of coal-mining transition counties. Among the factors that appear to play a role is a greater initial level of entrepreneurship in the successful counties, as well as the potential role that manufacturing played during the immediate period of the transition. Qualitative analysis points to necessary factors such as access to good highways and public investments, but such factors are not sufficient because less successful ARC counties also received large public investments.

- Section 6 more specifically describes the underlying economic development climate for each of the five case studies including the role of highways. This analysis draws upon publicly available information and interviews of key informants.

- Section 7 summarizes lessons learned and discusses some general policy guidance that stem from our research for the transition in all coal mining regions.

- Section 8 provides a summary of this report.

TECHNICAL ASSISTANCE FOR SUPPORT ENERGY TRANSITIONS IN COAL REGIONS
Socioeconomic Transition: U.S. Case Study

1. INTRODUCTION.

As nations transition from coal, winners and losers are created between regions and within affected communities. By examining communities that have already experienced an energy transition, policy makers can better support other communities that will face similar future challenges.

The purpose of this project is to assess the transition away from coal mining and its impacts on communities. A key goal is to address open questions about coal transition and to inform best practices to promote a "just transition" for affected community stakeholders as market realities and policies to mitigate climate-change force communities to adapt. Our focus is on Appalachia, a U.S. region that has been significantly affected by coal sector decline.

Appalachia is a mostly rural region spanning the Appalachian Mountain range, nearby foothills, and related areas such as the Shenandoah Valley. The region has historically lagged in terms of socioeconomic development. To address these perceived shortcomings, the Appalachian Regional Commission (ARC) was established in 1965. Today, it covers parts of 13 states and includes 420 counties. Though we will use the terms Appalachian region and ARC interchangeably, the ARC has expanded over time and covers more territory than traditional Appalachia.

For many decades, the region has been saddled with 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 producer dating back to the early 19th century, typically producing more than 80% 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% and fell to 27% in 2018 according to the U.S. Energy Information Agency (EIA) (2019).[1] While total U.S. coal production itself fell 6% over this 20-year period, Appalachian coal production fell by 41% (U.S. Energy Information Agency 2019). These changes along with the legacy of poverty in Appalachia make its coal-country communities particularly vulnerable to the fortunes of the coal industry.

As a result of the focus and limitations of past studies, a number of open questions remain in assessing Appalachia's transition away from coal mining. Our project aims to address these issues through a quantitative analysis of the region's communities from the post-World War I period, case-studies and synthesizing findings from previous studies. We focus on four analytical questions:

[1]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.

1) Which communities made a relatively more successful transition away from coal mining employment during the 20th century and up to today?

2) What were the resulting outcomes for socioeconomic conditions in these communities?

3) What factors mattered for the Appalachian communities that recovered more successfully?

4) What are the lessons learned from this project? What are the key factors that contribute to socioeconomic revitalization in transitioning away from coal?

This report is organized as follows. First, in the remainder of this section, we explain why past studies have been limited in terms of informing the questions above. In the second section, we draw together the literature on community well-being in periods of transition. In the third section, we provide an overview of changes in the coal industry. In the fourth section, address questions one and two above: we identify the communities that were most successful in transitioning beyond coal and the resulting socioeconomic outcomes. The fifth section documents factors that help explain why some Appalachian communities have fared better than others over the course of coal transition based on the quantitative and qualitative analyses. The sixth section more specifically describes the underlying economic development climate for each of the five case study counties including the role of highways. In the seventh section, we synthesize the findings to identify lessons learned and provide some general policy guidance. The final section provides a summary of this report.

1.1 Importance of this Study: Filling a Gap in the Knowledge Base.

The questions addressed are pivotal for understanding the transition process away from single industry dependence and for identifying the challenges and barriers to socioeconomic revitalization of communities. Yet the knowledge base for answering these questions is limited in scope and detail. We briefly note why existing work provides limited information from which to directly address the questions posed by this study on the transition from coal employment across communities.

First, while numerous studies address changes in the U.S. energy industry, much of the research is aimed at national trends rather than community-level outcomes. Such research tells us little about how populations adapt in affected areas.

Second, when turning to community studies by social scientists, most focus is on mining as an aggregate sector and/or other types of natural resource extraction. Studies rarely disaggregate coal mining in its community effects (Betz et al. 2015; Lobao et al. 2016). For example, researchers examined general boom/bust cycles in the energy industry and whether there is a "natural resources curse" in which natural resource intense locations have lower long-run growth rates when averaging over the boom-bust cycle (Van der Ploeg, 2011). Research on employment in the U.S. energy industry has also moved more toward assessing the oil and gas industry, which rapidly expanded after 2006.

Third, existing research on the impact of coal mining on communities tends to be case studies or otherwise limited in generalizability. Few systematic, quantitative studies exist in part because researchers have lacked detailed employment data that span small communities and they need to rely on secondary sources that typically aggregate all of mining.

Fourth, in the case of coal, systematic, quantitative research scrutinizing the industry's effects on communities in the recent period is rare. Prior studies for example focus on the boom/bust of the 1970s and 1980s (e.g., Black et al. 2005) or on the long-run 20th century natural resources curse (Deaton and Niman 2012). Some exceptions include Lobao et al. (2016) and Betz et al. (2015) who analyzed changes in coal employment and their impact on poverty, household income, and other variables over 1990-2010. As a result, little is known about the degree to which communities today experienced successful revitalization in light of their past coal dependence.

Fifth, for research examining coal communities, the factors that might lead to positive 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 (e.g. tourist industries) which would reflect the degree to which communities could transition to other economic sectors. Their study finds that Appalachian communities with a larger share of coal employment had lower entrepreneurship rates as measured by the share of local proprietorship employment. Historical studies of the region (e.g. Billings and Blee 2000) and community case studies (e.g. Duncan 2014) also explain how coal mining has impacted other areas of community development such as weakening the institutional capacity of local governments to address residents' needs. Thus, these studies point to the importance of considering a broad range of community factors that might influence future socioeconomic outcomes.

Another limitation is that in virtually all studies, researchers question the impacts (positive or negative) of coal or other mining employment (and change in this employment) on communities at single or specified point(s) in time. But (with the exception of case-studies), they rarely aim to assess the long-term consequences for communities that lose mining employment and transition out of coal mining. Nor have any studies to our knowledge determined the temporal period needed to make successful adjustment. For Appalachia, researchers simply do not know how successfully communities have adapted overall as employment has shifted away from coal in the post-World War II period.

Finally, there tends to be an analytical gap between empirical studies aimed at examining the community impacts of coal mining and studies aimed at policy formulation. In the first case, academic empirical studies typically give policy limited if any attention. Policy studies on the other hand tend to draw from a portfolio of commonly recognized community/regional development strategies; their recommendations and evaluations often center at a broad regional or sectoral-level (e.g. Appalachia or mining as a whole), or alternatively are highly localized in pertaining to specific communities. There appears to be a disconnect between empirical studies that delineate broad social, economic, and institutional factors that explain why some communities fare better—and between policy studies whose aim is cast narrowly on identifying or evaluating strategies for community revitalization that are politically and economically feasible.

Our project aims to address these knowledge gaps by: synthesizing the results of disparate studies that point to factors that promote community well-being and aid in successful transition; and through an empirical analysis of Appalachian communities from the post- WW I period to the present and case examples of specific communities. We aim to produce more consistent and generalizable information about community adjustment; to track communities over the long-term up to today; present and document the degree of recovery; and identify policy implications.

To analyze the impacts of a transition away from coal mining, we focus on communities and the recovery process. By "community" our unit of analysis is generally counties. We employ counties for several reasons: (1) this is the unit used by the Appalachian Regional Commission (ARC) to classify the region's communities; (2) the most complete local-level secondary data are county level; (3) counties are best suited to analyze change over time because their boundaries are much less likely to shift than boundaries of municipalities or other places; and (4) counties are the unit of analysis most often used in rural U.S. research (Isserman 2007; Partridge and Rickman 2006).

2. FACTORS RELATED TO PROSPERITY/POVERTY ACROSS COMMUNITIES: A SYNTHESIS OF RESEARCH FINDINGS.

In this section, we synthesize a wide range of studies to gauge factors that should be important in driving communities' recovery in the wake coal transition. We summarize the conclusions of this large and disparate literature by dividing it into: (1) studies that broadly focus on general factors that affect prosperity and poverty across U.S. communities and (2) targeted studies that examine cases of communities experiencing natural resource, energy, and other industry transitions. Again, as noted, insofar as disparate studies exist, consistent and generalizable information about the factors promoting the adjustment process are hard to come by.

2.1 General Factors Determining Prosperity/Poverty across Communities.

To determine the factors that matter for communities' recovery, it is useful to draw first from the large social science literature that analyzes the general question of *why* U.S. communities vary in their levels of prosperity/poverty. These studies identify persistent structural conditions in places that are barriers or facilitators to improved 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) share a thematic interest in the determinants of U.S. communities' socioeconomic well-being. Much of this work specifically addresses the structural conditions faced by rural America, making it useful for analyzing Appalachia.

For the purposes of our objectives, this research is used to identify the key structural factors that enable some communities to fare better than others, even as they may experience similar declines in coal mining employment. In this research, analysts commonly recognize three sets of structural determinants of communities' well-being: (1) geographic attributes such as regional location, urban-rural location, distance from metropolitan areas of varying size, and degree of urbanization including population; (2) local economic structure or the quantity, quality, and mix of local employment sectors; and (3) sociodemographic factors such as race/ethnicity, age, education, gender, and family structure that reflect residents' structural vulnerability.

Community socioeconomic well-being (e.g. 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 in the past though not so much today, 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 those with greater educational attainments, a higher working-age population, fewer single-parent female-headed households, and lower racial/ethnic minority population generally have lower poverty and higher income levels (Partridge and Rickman 2006; Lichter and Cimbaluk 2012; Voss et al. 2006).

In addition to the three sets of commonly studied determinants, we denote a fourth: local institutional factors such as local governmental capacity and social capital have been posited as promoting 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 better future community outcomes such as lower poverty/greater prosperity.

In sum, based on the large body of work on prosperity/poverty across communities, coal communities characterized by more favorable structural conditions above (i.e. geography, economic structure, a smaller vulnerable population) along with greater institutional capacity are likely to fare better in transitioning away from coal. Our empirical analysis particularly assesses these potential determinants of future success as they form an umbrella of factors known to affect the socioeconomic well-being of communities in general, as well as communities in resource dependent areas as noted below.

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

Turning to literature on natural resource and other transitions, we draw together more detailed findings about the determinants of success and revitalization. The four overall umbrella factors identified above are appraised in this literature as well. Yet this literature sees greater barriers historically in natural resource-based communities (relative to other communities) with regards to geographic location, economic structure, population vulnerability, and institutional capacity that would affect long-term revitalization. In other words, insofar as conditions historically have been less favorable for Appalachian mining communities, the starting point to attain success is likely behind that of other communities that do not have a mining legacy.

2.2.1 Falling behind and getting ahead: the resource curse and related frameworks.

Overlapping social science frameworks stress why resource-dependent regions historically have tended to fare poorer than elsewhere. Most broadly, the nature of extractive industries is often noted: they manifest a history of exploitative relationships, distinct phases of development, embeddedness in non-local markets, and susceptibility to boom-and-bust shocks that stand to negatively affect communities (Freudenburg and Wilson 2002). In economics, the concept of the "natural resource curse" is often used to explain why natural resource intense locations appear to have lower long-run growth rates when averaging over the boom-bust cycle. Here communities lag over the long term due to 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 overadapt to extractive industries, so that populations' expectations and community institutions revolve around the industry, with inevitable busts becoming particularly devastating. Extractive communities are prone to developing overly specialized economies in which future diversification is difficult to achieve. "Flickering" or periodic shutdowns tend to increase unemployment (Freudenberg and Wilson 2002). Finally, through this literature, the general process of path dependence is noted:

extractive industries give rise to self-reinforcing development paths that include displacement of other industries, less diverse local economies, underinvestment in education and lower human capital. The points along with the remote rural location of many extractive communities provides a rationale for expecting that revitalization is likely to be long and challenging.

2.2.2 What matters to getting ahead?

To address the factors that facilitate successful transition and those that are barriers to recovery in our case of Appalachia, we narrow our focus through a targeted literature review. As discussed, few if any generalizable empirical studies document the ingredients needed by Appalachian/U.S. communities for successful transitioning from coal employment. We therefore undertake a targeted search of studies that can provide information about transitions experienced by communities that shared some similarities to our case. We aim this search to cover economic shocks and changes in small and rural communities. Given our focus, we aim to incorporate shocks due to energy/natural resource transitions such as: coal, oil and gas production; support activities for coal and oil/gas industries; electric power generation; petroleum refining; and natural gas distribution. We also appraise other sectors such as military base closures with these bases often found in small communities. Finally, we include the existing empirical studies on changes in coal mining and its effects on communities.

The methodology of selecting and classifying studies is explained in detail in Appendix 2, Table 1. The results are based on published refereed articles from academic journals, as well as reports from governmental and non-governmental agencies. Our findings are based on 37 articles we find most relevant to our research questions. Because our focus is on the "just-transition" in the United States and because we aim to draw parsimonious conclusions for researchers and policymakers, we exclude literature where that nation was not the centerpiece. Other criteria for selection of the articles are noted in Appendix 2. The included literature summarized in this report represents the major research on the topic, but due to selection criteria and the inherent limitations of research reviews, they are not exhaustive of past work.
As shown in Appendix 2, the studies analyzed are varied in methodology, thematic areas of focus regarding a shock or change, and impact indicators. Nevertheless, we can draw some generalizations.

- While mining is a very small share of U.S. employment, large-scale quantitative studies that examine changes in this sector (coal and otherwise) tend to find statistically significant impacts on community poverty, income levels, employment and population growth, and other forms 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). These effects are evident for the U.S. and are not just confined to Appalachia. While noting this finding might seem obvious to those concerned with "energy/coal transition"—it is important to note that this is not necessarily the case when employment in other industries such as service sectors are analyzed in quantitative studies; often, such sectors exhibit no statistically significant impacts across communities. In other words, mining is one U.S. industry that appears to differentiate communities that win or lose in the national economy.

- The time period with respect to change matters. The community impacts of mining in general (Freudenburg and Wilson 2002) and coal mining in particular (Betz et al. 2015; Black et al. 2005; Lobao et al. 2016) tend to be positive in times of price upswings and negative with lower prices. The uncertainty makes it difficult for communities to adjust over the long-run to the "natural resource curse." Haggerty (2014) finds that the longer counties specialized in oil/gas (over a 30-year period), the lower the future education and income. The boom/bust cycle has implications for local support for extractive industries. As noted, Freudenburg (1992) finds that communities overadapt to extractive industries, with residents assuming that busts are temporary and that conditions will return to more normal "prosperity" as booms eventually reoccur. Extending this finding, the residents' receptivity toward diversification through alternative or non-mining industries potentially will vary depending on whether or not the period is a price upswing.

- The region where transition occurs seems to matter. In the case of resource extraction, communities in southern 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 the relatively poorer structural conditions (e.g. poorer quality jobs, lower education) faced by southern rural communities. (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).

- A community's structural characteristics matters for successful adaption. As discussed above, these key characteristics are identified in the literature on poverty/prosperity across communities. In particular, three sets of barriers stand out: geography and the degree of remoteness from cities (Douglas and Walkers 2017; Haggerty 2019; Haggerty et al. 2018; Snyder 2018); the degree to which alternative economic opportunities are available, overspecialization where mining appears to crowd-out other industry sectors (Carley 2018; Deaton and Niman 2012; Haggerty 2014; Haggerty et al. 2018); and population vulnerability as indicated by relatively low educational attainments in extractive regions (Douglas and Walker 2017; Haggerty et al. 2018), and an aging workforce (Haggerty 2019). These structural barriers affect workforce upgrading: low digital literacy limits job searches and occupational mobility; transportation becomes important to access college and training centers, as well as employment elsewhere (Jolley et al. 2019). Conversely, training, community college programs, and new professional opportunities including those in alternative energy industries have been found to improve coal community residents' ability to adapt to change (Carley et al. 2018).

- The quality of the local environment and the presence of natural amenities matter. Locally environmentally degraded conditions hamper 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 populations, especially retirees (Isserman et al. 2009; Partridge and Olfert 2011)

- Research on subjective perceptions suggests that populations experiencing transition are keenly aware of the barriers faced by their communities. The barriers recognized by locals are similar to those found in studies using objective quantitative (i.e., socioeconomic) indicators. Studies using surveys (Besser et al. 2008; Graffe 2019) and focus groups (Carley et al. 2018) report that local populations recognize barriers such as lack of alternative employment, low education, and boom/bust economic cycles that characterize communities. In Appalachia, residents' concerns about their community moving away from coal to more non-coal employment include: fear of potential job loss and business closures in other local industries; detrimental effects on schools and retail as families migrate out; and mobility barriers due to lack of affordable housing elsewhere and high attachment to the community itself (Carley et al. 2018).

- Some research indicates the presence of a "coal culture" that can function as a barrier to transition in Appalachia. Carley et al. (2018) notes that coal mining employment over generations creates a community bond and identity with the industry. Haggerty et al. (2018) point out that resistance to change can come when populations' place blame on restrictive environmental regulations, while ignoring larger role of markets, particularly price competition with natural gas. Carley et al. (2018) notes that promising a return of coal jobs is damaging to community and individuals' efforts to adapt to change. Long-term dependence on coal delays acceptance of a transition away from the industry but in any case, populations find it difficult to move elsewhere (Haggerty 2019).

- Rural communities are not homogenous and the benefits/costs of transition vary by social groups affected. For example, Appalachian communities with greater share of coal employment tend to have a lower share of sole proprietors, higher disability rates, and a proportionately higher share of poor people (Betz et al. 2015). Much has been written about the uneven impacts of the natural gas expansion, with communities divided among those in a respective community who benefit from gas/oil leases and those who don't. As extractive industries employ a higher proportion of men, women tend to have fewer local employment opportunities; declines in extractive employment affect the families of male workers and family structure and may cause an increase in the share of households that are female-headed with children (Cook 1995).

- Institutional barriers that are identified in the studies reviewed are of two key types: the quality and capacity of local governments and local social capital.

    1. Communities with higher levels of social capital tend to be more resilient. In the case of plant closures, Besser et al. (2008) find that residents' reports of overall quality of life are less negative where social capital as measured by strong inter-group relationships within the community is higher.

2. Barriers related to local government capacity for rural and small U.S. communities have long been noted (Johnson et al. 1995; Lobao and Kelly 2020). This lack of capacity has likewise been documented in studies reviewed here that address transition planning (i.e. there are few empirical analyses of actual transitions). The overriding problem that local governments are noted to face is replacing and stabilizing income streams (Haggerty et al. 2018).

   Haggerty (2019) provides a summary of barriers faced by small or rural governments in the case of coal plant closure: limited administrative leadership capacity (e.g., little or no planning staff); limited staff capacity, so the communities lack grant staff capacity to apply for federal and state assistance; weak ties to state or regional actors which limit access to regional and state support for transition; lack of fiscal autonomy – state restrictions limit local budgeting authority. Haggerty et al. (2018) and Haggerty (2019) stress that small communities often lack access to a dedicated transition fund that affects local budgets; local governments have to substitute other funds or negotiate to secure external funds. They lack adequate information to assess fiscal risks and the limitations imposed by state and federal fiscal policies (Haggerty 2019). In an empirical analysis of the impacts of coal-power plant closures in an Appalachian county, Jolley et al. (2019) draw similar conclusions as the above planning studies, noting that Appalachian local governments have limited fiscal resilience and ability to recover from lost taxes.

- In terms of local policies, while variety of conventional economic development policies and incentives aimed at external business attraction, local business retention and workforce development policies, are appraised in the studies reviewed, taken as a whole they yield the following generalizations. A) Economic development policies have benefits as well as costs for rural areas, the benefits typically appear to be modest (Daniels et al. 2000), and there is an overrepresentation of strategies focused on retaining or attracting a single large employer (Haggerty et al. 2018). B) No policies/programs work or potentially could work everywhere. C) Successful models appear difficult to replicate. D) Outcomes have been difficult to evaluate; there are complexities in any single case and there are ambiguous results across studies.

- Military base closures, while likewise often affecting small communities, is different from transitions in private sector extractive industries in a key respect. In military base closures, planning is long established with rigorous a protocol for engaging local communities following the federal Base Closure Act. The Department of Defense makes economic development grants and technical support available to assist communities in executing a redevelopment plan for the property. Cowan (2012) notes that while rural relative to urban communities typically find it harder to recover from loss of a military base, he did not find strong effects.

- Federal policy historically has been limited in addressing the needs of rural communities. The U.S. has treated agricultural-policy as its primary rural development policy, focusing on the needs of the farm population as opposed to the much broader needs of the rural nonfarm population. In place of a general rural development policy that would focus on communities' economic development, infrastructure and facilities, rural areas rely more on income security transfers targeted to individuals such as disability (Bishop 2017). Haggerty et al. (2019) in the case of coal plant closure notes that federal assistance is over-prescribed and poorly targeted – limiting local autonomy and flexibility to use funds to meet locally defined needs. Local governments tend to lack adequate information to assess fiscal risks and the limitations imposed by state and federal fiscal policies. Various programs have offered assistance to resource transition areas. For example, the Appalachian Regional Commission (ARC) has long provided grants and other programmatic assistance to Appalachia communities. The federal POWER (Partnerships for Opportunity and Workforce and Economic Revitalization) initiative established under President Obama offers a tool-kit of commonly recognized community development strategies to provide workforce training and economic development assistance in Appalachian coal communities with the goal of increasing regional economic diversification, job creation, capital investment, and re-employment for displaced workers. To be sure, the POWER program does not offer any true innovations in economic development. As of fall 2019, it funded grants at over $190 million for 239 projects that are located in 326 ARC counties. However, Morris et al. (2019) note that the wider goals of the plan to have $9 billion in federal aid have not been realized.

3. COAL MINING PAST TRENDS, CURRENT STATUS, AND FUTURE EXPECTATIONS.

3.1 Coal Mining in the United States and Appalachia: An Overview.

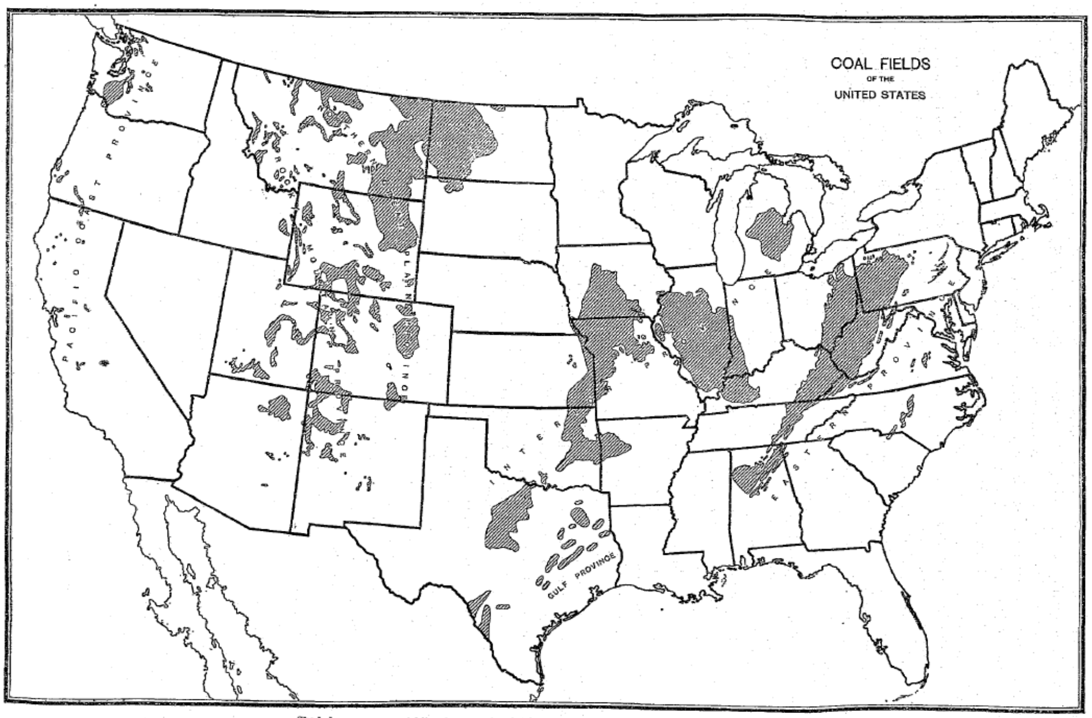
Figure 1 shows continental U.S. coal fields as delineated in 1919 and Appendix 1, Figure 1 reports U.S. coal fields from a contemporary perspective. A careful look shows that the maps do not tangibly vary in terms of the location of the reserves, though contemporary analysis has a more accurate view of the remaining coal reserves and its quality in each region. It is easy to see the large swath of coal fields in Appalachia running from Pennsylvania through central Appalachia, ending around Birmingham, Alabama at the far-southern extent of Appalachia. The key competitors 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. Figure 2 reproduces a map from the 1954 *Census of Mining Industries* that shows employment concentrations in mining, in which each dot represents 100 employees. The heavy employment concentrations in the region where Ohio, Pennsylvania, and West Virginia meet illustrate rich bituminous coal fields, whereas concentrations in northeastern Pennsylvania are high-quality anthracite coal fields used in ferrous metallurgy. The southeastern Kentucky/southwestern West Virginia coal fields are another particularly rich region. Note the small cluster around Birmingham, AL. The Birmingham region is 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, Appalachian coal mining accounted for about 66% of U.S total mining employment. Yet, with falling transportation costs, Appalachia's productivity advantages over other U.S. coal mining regions led to its employment share rising to 85% by 1954. Appalachia's dominance began to wane after the mid-1960s as its coal-mining employment share fell to about 80% in 1972, as western coal began its initial accent. Appalachia's coal-mining employment share further declined to about 73% by 1984, falling to 67% by 2002. Despite a pause in the 2000-2012 period, this downward trend continued thereafter until Appalachia's share reached 57% in 2018. (*Census of Mineral Industries*, various years; EIA, various years).

Figure 3 shows U.S. coal employment and production in short tons over the 1919 to 2017 period. Coal production modestly increased in the post-World War I era until 1929, before declining by almost one-third by 1954, initially due to the Great Depression and then a substitution away from coal towards less expensive fuel sources such as oil and gas (along with technological changes such as the switch to diesel locomotives). Strong economic growth after 1954 and rapid coal-mining productivity growth reversed the downward trend as coal production rose over 250% by 2002. Afterwards, coal production plateaued until about 2012, before declining about 30% by 2017. Multiple reasons for this rapid decline include a challenges in coal export markets, low-cost natural gas, and growing competitiveness of renewable energy sources.

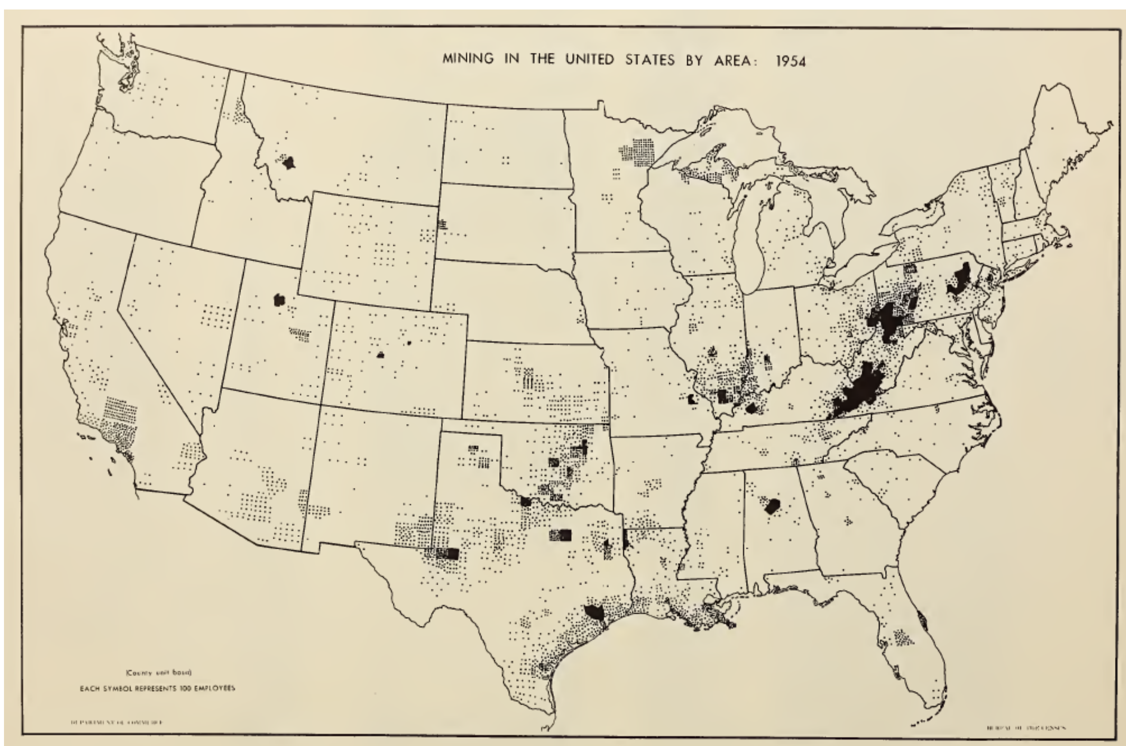
Figure 1: Coal Mining Fields in the Continental United States, 1919



Shaded areas represent bituminous coal; solid black area (Pennsylvania) represents anthracite coal.

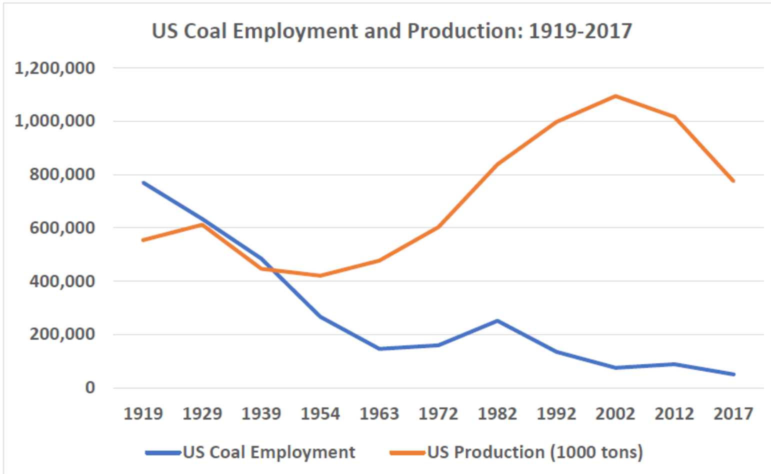
Source: *1919 Census of Mineral Industries, p. 254.*

Figure 2: 1954 Mining Intensity for Employment (each dot = 100 mine workers)



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

Figure 3: US Coal Employment and Production



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

3.2 Shifting Geography of U.S. Coal Production and Coal Productivity Trends.

Changes in coal production have not been uniform across U.S. regions owing to several factors (Betz et al. 2105; EIA 1999, 2005, 2013). First, increased productivity of western coal (especially Powder River Basin in northeastern Wyoming) increased western coal sales. Second, environmental regulations from the Clean Water Act of 1972, Clean Air Act of 1970, and Clean Air Act of 1990 increased demand for low-sulfur Western coal. The 1970s began a massive increase in Western coal production, especially from the Powder River Basin (PRB) of Wyoming and southeastern Montana. PRB coal is relatively inexpensive to strip mine with little surface overhang, very thick coal seams, and high-quality coal (EIA 2001). The Wyoming State Geological Survey describes the production-cost advantages of the PRB coal as:

> "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."[2,3]

By the 1970s, these lower costs became a "compelling" reason to mine western coal versus developing other energy sources (EIA 1979). PRB coal is also relatively low in sulfur dioxide,

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

[3] Appalachian coal typically has a moisture content of only about 7%, which gives it a higher heating value than PBR coal. Yet, Appalachian coal has about one-and-a-half-times more ash, which is the toxic residue that remains after burning coal, about two- to five-times more Sulphur that 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).

mercury, and arsenic, giving it additional competitive advantages due to tightened environmental regulations (EIA 1979, 2001).[4]

Coal is very bulky and expensive to transport, which historically gave Appalachian coal mines an advantage due to their proximity to major eastern cities and manufacturers. The remoteness of the PRB and its historical weak rail links gave Appalachian mines a transportation advantage. Improved rail transportation from PRB mines beginning in the 1970s augmented the region's cost advantages (EIA 2001). Today, 50 to 70 coal trains leave Wyoming every day to 29 states that consume its coal, with the largest consumers being Texas, Missouri, and Illinois.[5]

The shift in coal production away from eastern regions was rather swift. Eastern coal (mostly Appalachian) accounted for 93% of U.S. coal production in 1965, falling to 74% in 1978, while the respective shares for western coal (increasingly from the PRB) was 4% in 1965, sharply rising to 25% by 1978 (EIA 1979). Separating the interior into east and west of Mississippi yields a 61% share for the east (47% from Appalachia) and a 39% western share in 1990 (EIA, 1993). Falling transport costs and more stringent environmental regulations that favored western coal led to the western coal share rising to 52% by 2000 and the eastern share falling to 48%, and specifically, Appalachia's national share was 38%.

Innovations in unconventional shale drilling for oil and natural gas led to exploding growth in oil and gas production after 2005. Low natural gas prices led to natural gas substituting for coal. Expected future climate-change regulations have reinforced the increased demand for gas (and renewables) relative to coal because coal's CO^2 emissions are about double those of natural gas. Illustrating the effect of the shale boom, coal consistently accounted for 48% to 53% of U.S. electricity generation from 1990–2008 before falling to 37% in 2012 and 24% in 2019; by contrast, natural gas's share of electricity production rose from 12% in 1990 to 30% in 2012 and 37% in 2019 (EIA 2013, 2020). Appalachian producers have been further squeezed as the northern Appalachian Marcellus Shale play became a key supplier of natural gas. By 2019, Appalachia's share of U.S. coal production declined to about 26%, with western coal accounting for 55% (if the western share also includes western-interior coal fields, its share rises to 59% and the corresponding eastern share is 41%) (EIA 2020). In sum, the falling usage of coal in the last decade and the 50-year redistribution of U.S. coal production to the PRB has had devastating impacts on Appalachian coal country, leading to mine closures and layoffs.

Large numbers of older 1950-1980 era coal-power plants have been retired since the Great Recession. Just between 2011 and 2017, the capacity of U.S. coal-fired power plants decreased nearly 20%, with more expected closures to occur.[6] Renewable energy is also forecasted to surpass coal as a source of U.S. electric generation in 2021.[7] Scores of U.S. coal companies have

[4]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).
[5] Wyoming State Geological Survey. https://www.wsgs.wyo.gov/energy/coal-production-mining. (downloaded April 30, 2020).
[6] 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).
[7] 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).

filed for bankruptcy in recent years including giants Peabody Energy, Cloud Peak Energy, Arch Coal, Murray Energy, and Alpha Natural Resources.[8]

There is no relief in coal's near- and long-term outlooks. During the current Covid-19 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 renewable energy technologies are less expensive for electricity generation than coal in much of the country. Thus, the first fuel source taken offline is coal power plants. With coal demand declining due to both less electricity demand and coal providing a smaller share of energy, the EIA's revised *post-Covid-19* forecast is for a 22% decline in U.S. coal production for 2020. There was a remarkable 41% annual drop in U.S. production in the week ending May 9, 2020, with Appalachia taking a disproportionate hit.[9] Medium- to long-term, *pre-Covid-19* forecasts of coal's share of electricity generation are for further declines to 17% in 2025 and 13% in 2050, while natural gas's share plateaus to 37% in 2025 and 36% in 2050, with renewables increasingly a key competitor (EIA 2020).

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

The history of U.S coal mining employment in the last century is one of further concentration into Appalachia until the mid 20th century followed by a deconcentration with coal mining migrating westward, especially to the PRB in Wyoming. Even within Appalachia, the last century has been a spatial movement from Pennsylvania and northern Appalachia to central Appalachia centered on the region where the Kentucky, Virginia, and West Virginia meet. As coal mining moved, its employment rapidly declined, mainly driven by labor-saving productivity growth.

To better understand trends in productivity growth, we use an updated version of Betz et al.'s (2015) data to construct an *annual* coal employment data series for 1929 to 2019. This series is presented in Appendix 1, Figure 1.

The pattern of rising coal productivity is illustrated in Figure 4. It shows average labor productivity measured as tons per coal employee. From 1919 to 1939, average labor productivity grew a modest 1.2% annually, further accelerating to 3.6% from 1939 to 1954. This productivity bump is likely a key cause behind the 50% decrease in employment just between 1948 and 1954. Annual labor productivity growth between 1954-1963 accelerated to 8.5%, creating sharp 50% total employment decline despite rising coal production (see Figure 3). Beginning in the late 1960s, steady economic growth and rising energy prices due to supply constraints for oil and natural gas led to a resurgence of coal demand. The ensuing search for new coal led to falling productivity. The result was an 83% increase in mining employment between 1968 to 1982. The 1970s coal boom was the only sustained boom that occurred since World War I

The "popping" of the 1970s/early 1980s energy boom restored the long-term process of rising mining productivity leading to declining coal mining employment—though environmental

[8] See https://en.wikipedia.org/wiki/Coal_mining_in_the_United_States (downloaded April 30, 2020).
[9] 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).

regulations provided an additional headwind after the passage of the Clean Air Act of 1990. U.S. coal employment declined 68% between 1982 and 2000. Figure 4 shows that productivity increased 440% over the 1982-2020 period (or 8.6% annual growth), contributing to falling employment.

A key contributor to rising productivity from the 1970s to the early 2000s was the ongoing geographic shift of coal mining from lower-productivity Appalachian (and Interior U.S.) mines to higher-productivity western strip mines. Wyoming, for instance, has produced about 40% of U.S. coal for the last decade, with 96.5% of the state's coal from Campbell County in northeast Wyoming.[10]

Figure 4: US Coal Labor Productivity

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

Wyoming's largest coal mine, the Peabody Energy North Antelope Rochelle Complex, produced more than 98 million tons in 2018, or 3 million tons more than produced in all of West Virginia.[11] Remarkably, Wyoming's 304.2 million tons of 2018 coal production was mined by only 5,558 workers, barely one-tenth of total U.S. coal employment.[12] By contrast, Appalachia coal mining employed 30,620 in 2018. It is unsurprising that productivity per coal worker (tons/worker) was 8.4 times greater in Wyoming than in Appalachia.

Coal experienced a mini-resurgence between 2001-2012 due to shift in electricity generation and expanding global markets. Coal employment was also supported by an annual decline in productivity growth of -2.4% between 2002-2012. Coal mining and coal-mining support jobs increased 23% over the 2002-2012 decade. Yet, coal had transformed into such a relatively small industry that favorable pattern created only 18,000 more coal mining jobs.

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[10] Wyoming State Geological Survey. https://www.wsgs.wyo.gov/energy/coal-production-mining. (downloaded April 30, 2020). 2018 Wyoming nonfarm employment is from BLS CES.

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

[12] 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).

The post-Great Recession years were a return to hard times for the coal industry. The shift from coal-powered electric generation to natural gas continued and productivity growth rebounded. 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). U.S. coal employment and coal-mining support industry employment fell 41% between 2012 to 2019 to about 56,000 employees. Coal mining & support accounted for just 0.0037% of total nonfarm U.S. employment in 2019. For comparison, there were 777,000 coal-mining jobs in 1919, or about 2.0% of total U.S. employment or 2.8% of U.S. nonfarm employment (U.S. Census Bureau 1975 and 1999, U.S. Census Bureau Statistical Abstract, Table 1432).[13] National coal mining employment peaked at 863,000 in 1923 (U.S. Census Bureau 1975), meaning coal jobs declined by approximately 807,000 over the next 96 years, or by 94%.

3.4 Coal Employment within Appalachia.

Figure 5 presents the Appalachian version of the national trends. The ARC story is one of decline but with a spatial realignment from north to central Appalachia. Pennsylvania had just over 300,000 coal miners in 1919, nearly 3.5 times second-place West Virginia. The decline in north Appalachia's coal industry began right after World War I, while central Appalachian coal industries began their decline in the World War II era. Nevertheless, central ARC states had either smaller percentage declines or larger percentage increases in coal employment between 1939-2012. For example, while northern ARC coal states, Pennsylvania and Ohio did not have any period of sustained employment increase in the 1919-2017 period (1963-1982 was one of stagnation), central-Appalachian state coal industries experienced mini-booms with increased employment in the 1963-1982 and 2000-2010 periods. Yet, the bust-periods in other post-World War II periods vastly overwhelmed any positive employment effects in central Appalachia.

By the 2012-2017 period, central- and northern-Appalachia state coal employment tracked each other down. One take-away is that the central-Appalachia coal industry has followed its northern Appalachian neighbors with a lag of 20-30 years. Over 1919 to 2017 period, West Virginia's coal-mining employment decline was a "mere" 85%, similar to its central Appalachian neighbors Virginia and Kentucky, whose respective declines were 78% and 85%.[14] More striking is Ohio and Pennsylvania both had 98% coal employment decreases during the period.

For all three states, especially West Virginia, coal mining was critical for their respective state economies through the 20th century. State-level *total* employment data was not collected until the Census Bureau's *1930 Census of Unemployment.* Prior to that, the federal government only collected employment in selected industries including coal mining. In 1930, PA, WV, and KY coal mining respectively represented 7.3%, 22.7%, and 9.7% of their state's nonfarm

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[13]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).

[14]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).

employment. However, by 2017, coal mining respectively represented 1.9%, 0.3%, and 0.1% of 2017 WV, KY, and VA total nonfarm employment (EIA 2019 *Annual Coal Report;* Bureau of Labor Statistics state employment data).[15]

Even though President Trump campaigned in 2016 promising that if elected, he would "bring back" coal and its jobs, U.S. direct coal-employment fell from 51,000 in January 2017 when he entered office to 43,800 in April 2020 (BLS, CES). 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. Illustrating the shrinking footprint of coal, Walmart employs 1.5 million U.S. workers while retailer Bed Bath & Beyond employs about 65,000.[16] "King Coal" of the 20th century appears to have abdicated.

3.5 The Evolving Spatial Variation in Appalachian Coal Mining.

Overall there were 110 Appalachian counties that had measurable coal employment in 2016 with an overall average coal employment share of nonfarm employment equaling 3.7% for those counties. Among all 420 ARC counties, coal's nonfarm employment share averaged just under one-percent (0.98%) in 2014; the national average was even lower at 0.23% (figures calculated by the investigators).

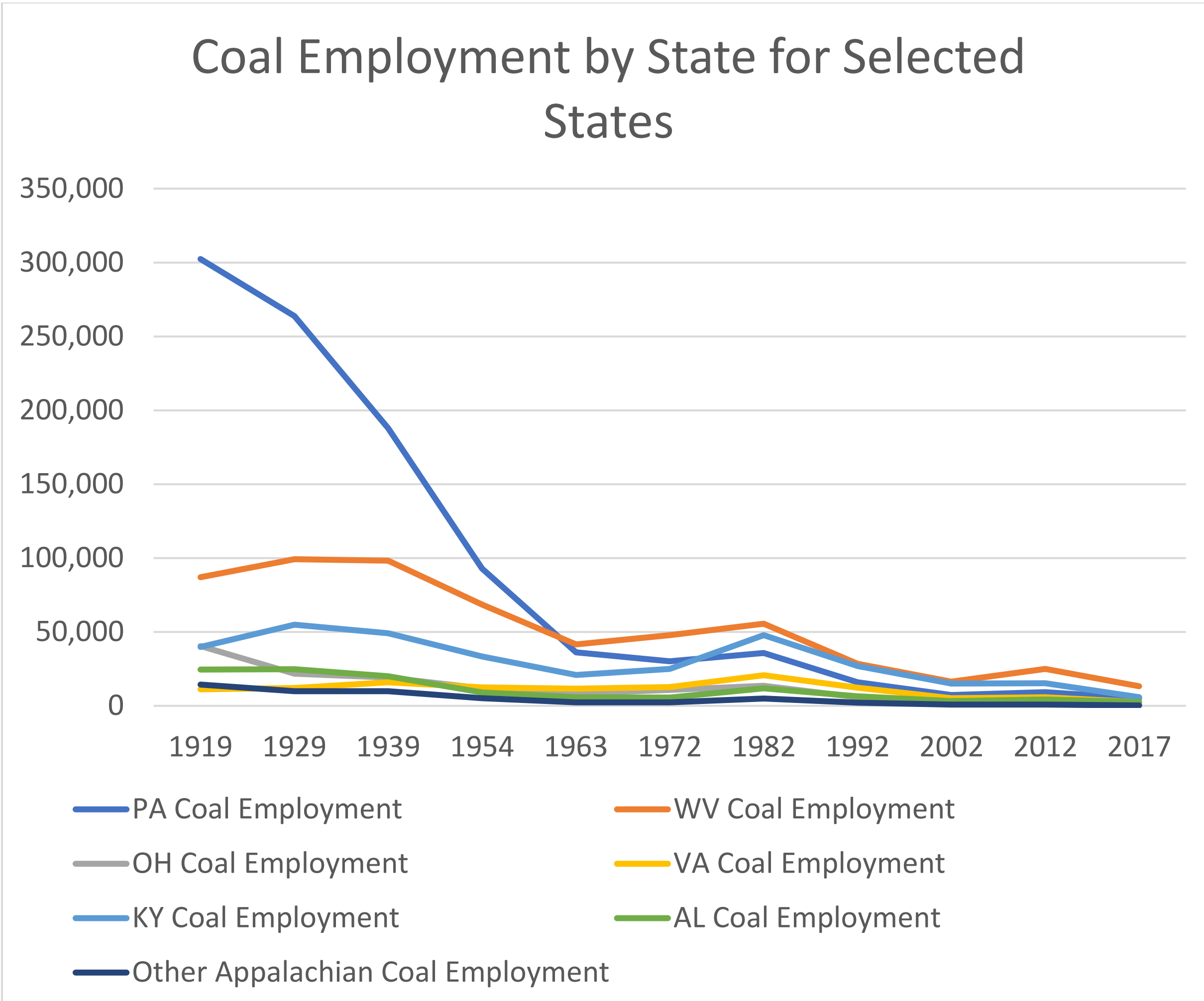
Figures 6 and 7 show the historic evolution of local economic dependence on coal mining in Appalachia. Figure 6 shows the 1950 residential share of the civilian labor-force working in mining, which for most of Appalachia is almost exclusively coal mining (especially in 1950). Appendix 1, Figures 3 to 9 reproduce state maps from the 1954 Census of Mineral Industries that show the high-coal intensity local economies in key Appalachian coal states of Alabama, Kentucky, Ohio, Pennsylvania, Virginia, and West Virginia.[17] Turning to contemporary Appalachia, Figure 7 shows the (place-of-work) 2016 employed coal mining share of the civilian labor force. Both Figures 6 and 7 include an additional 100-mile buffer 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 equal numbers of counties.

Figure 5: Coal Employment by State

[15] 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.

[16] 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).

[17] 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%.



Notes: 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/).
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.
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).

Figure 6 shows the top one-sixth of ARC counties had a mining employment share of over 40.67% in 1950. A mining share greater than 22.4% placed a county in the top one-third of ARC counties. The highest shares generally go down the spine of the Appalachian Mountains from Pennsylvania to Birmingham, AL, are especially dense running from Pennsylvania through West Virginia and Kentucky. Outside the ARC boundary, there are very-low mining employment shares on average. One exception the coal region near where Kentucky, Illinois, and Indiana meet, forming a key “Interior” coal region.

Mining shares understate the true size of mining in the mid-20th century, especially for more populated counties. Appendix 1, Figure 10 combines the information in Appendix 1, Figures 3-9 by reporting the number of 1950 residents employed in mining for each ARC county. What is apparent is the sheer number of counties having at least 1,097 coal employees, which are typically found through Pennsylvania to the northeast tip of Tennessee, as well as near Birmingham.

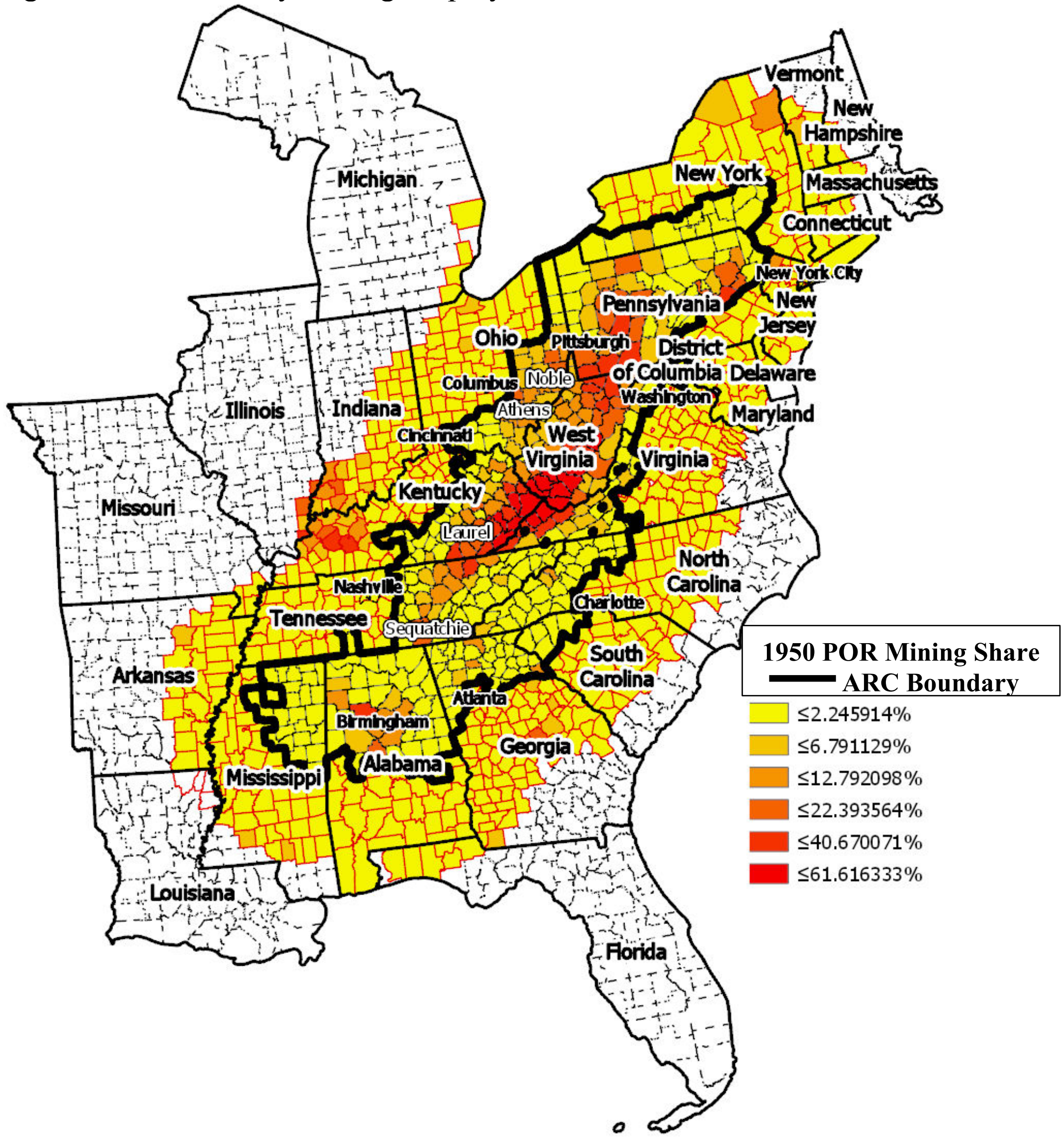
Figure 7 shows that the coal-mining intensive regions are mainly unchanged, though the most-intense mining regions are retreating back into the far-southwestern tip of Pennsylvania and northern West Virginia, and into the area near where Kentucky, Virginia, and West Virginia converge. It only takes a coal share above 17.4% to be in the highest-1/6th category and only above 11.5% to be in the next-highest 1/6th category. Regarding the highest-15 coal-intensive county economies, their nonfarm coal mining employment shares range from 8.2% in Fayette County in southern WV to 33.7% in nearby Boone County, WV. The second highest nonfarm coal mining employment share is 24.0% in Buchanan county in far southwest Virginia, being the only Virginia County directly bordering both Kentucky and West Virginia. For those who want to see the precise location of these counties, consult the state maps with county names in Appendix 1, Figures 3-9.

Of the top-fifteen most coal-intensive counties, 9 are in WV, one is in PA, one is in OH, one is in KY, one is in VA, and one is in MS.[18] Nine more had coal-mining employment shares above 5% (4 in WV, 2 in OH, and one each in KY, MS, and VA). The ARC region has 5 counties with a coal employment share above 20%, which likely means those county economies are dependent on coal. The ARC has 6 counties with mining shares between 10% and 20%, meaning that their economies are at least "semi-dependent" on coal. Thirteen ARC counties coal shares between 5% and 10%, which suggests that coal is important, but being dependent on coal may be a stretch. Overall, 5.7% of the 420 ARC counties have coal mining employment shares over 5%.

West Virginia has the largest concentration of counties in which coal mining remains an economic driver, having 13 WV counties with coal mining shares above 5% out of a total of 55 counties. There are a few other cases where coal mining remains important even as its share is not over 5%. 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%. Other ARC counties with over 1,000 coal miners, but with a coal employment share below 5%, are Kanawa County, WV (home of WV's capital Charleston) and Jefferson, County, AL (home to Birmingham).

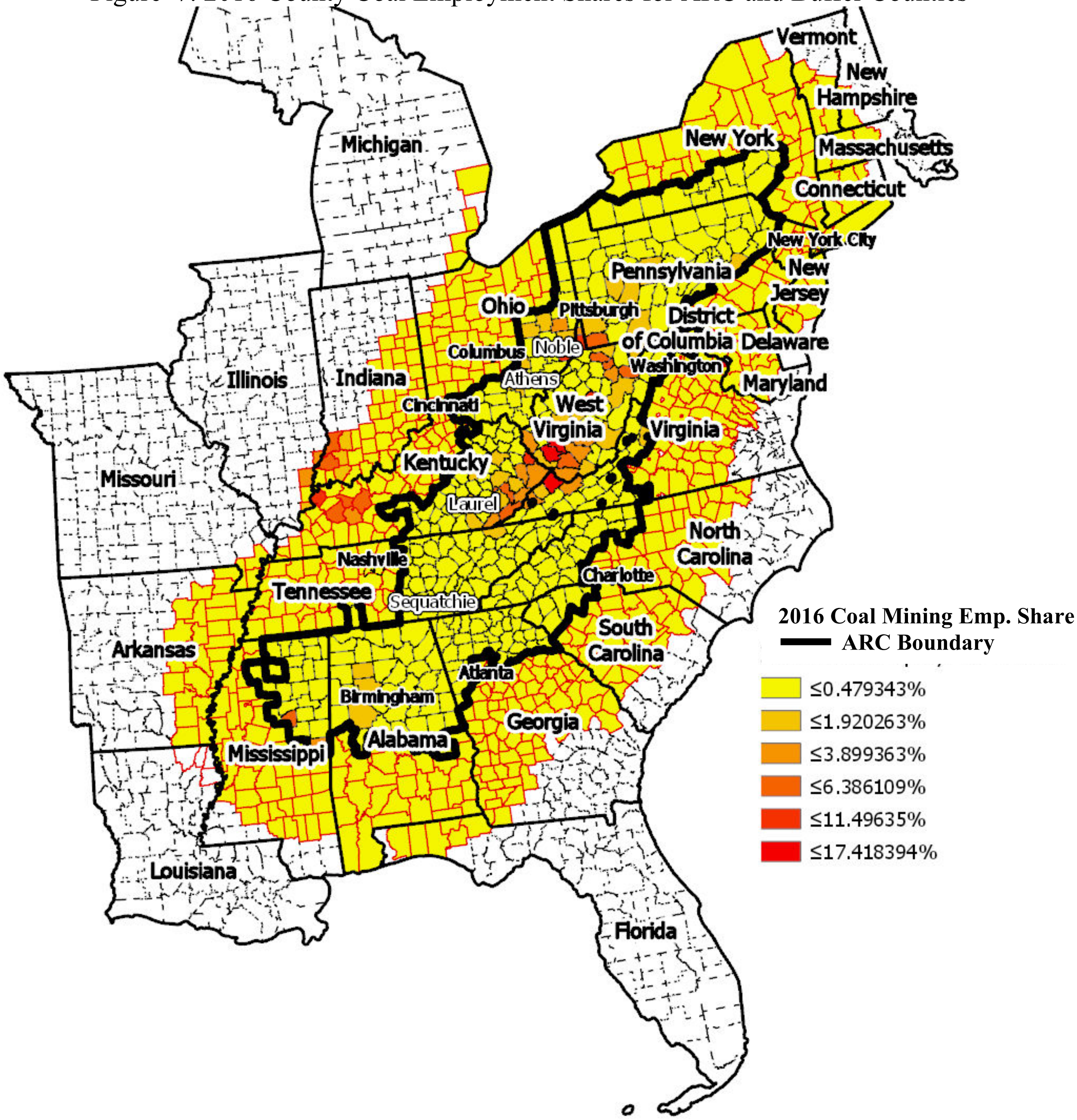
[18]The one Mississippi coal county is in an isolated small coal region at the far-western border of the ARC. There were only 199 MS coal miners in 2018 (EIA, 2020). Many ARC counties in Alabama and most in Mississippi (and in some other states) are not typically thought of as Appalachian. They were not originally included in the ARC when established in 1965, but were later added over time as the ARC grew from its original 360 counties to 420 today. The later additions often represented political log-rolling to expand Congressional support for the ARC.

Figure 6: 1950 County Mining Employment Shares for ARC and Buffer Counties



Source: 1950 Place of resident mining employment share 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.

Figure 7: 2016 County Coal Employment Shares for ARC and Buffer Counties



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. Outside the ARC region is the 100-mile buffer of counties.

4. IDENTIFYING SUCCESSFUL APPALACHIAN COAL TRANSITION COUNTIES.

In this section, we address the first two research questions of this project.
1) Which communities are relatively more "successful" in their economic transition away from coal mining employment?
2) What are the resulting outcomes with a different set of indicators **after** our selection of the selection of the successful cases?
3) Section 5 will address what are the potential causes for our selected counties' success.

4.1 Methodology to Identify the Counties that Successfully Transitioned Away from Coal, 1950-2018 Period.

To select counties that transitioned away from coal mining and became at least "somewhat successful" requires the following conditions:

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

2. The county is no longer dependent on coal mining today. All condition 2 means is that a county cannot successfully transition from coal unless coal mining is absent for a period of time, or the coal industry became very small.

3. At some time after coal mining had ceased, or had become a "trivial" part of the local economy, the county's economy prospered. Of course, being economically "successful" is somewhat in the eye of the beholder. As discussed, coal mining employment has rapidly declined and we will describe how the average coal mining community struggled relative to other communities.

Given the above conditions, we set out the following steps to identify the relatively successful transition counties.

4.1.1 Selection of success metric: population growth.

1. We selected *population growth* as the metric to base relative success upon. Population growth is the most common metric to assess regional success in U.S. regional studies and Betz et al. (2015) found that population growth is highly responsive to coal mining, being (strongly) negative related to the intensity of coal mining employment in the local area, and they found coal mining's effect to be statistically significant in a causal fashion. There are other metrics that are often associated with economic prosperity such as per-capita income, poverty rates, growth in median household income. Yet, population growth captures all of these as well in that people in- and out-migrate from these regions based on these factor economic factors as well as other socioeconomic factors.

   The standard model of American urban and regional economics is the Spatial Equilibrium Model (SEM), which posits that people tradeoff income and quality-of-life and locate in the place that gives the most satisfaction (Faggian et al. 2012; Partridge 2010). For example, it is unclear if, for example, low median household income is necessarily a sign of failure because it could reflect a high-quality of life. The SEM's main assumption is free mobility of households, which is more likely to apply over the 10-year spells we directly consider. Yet, for low-income households with income or information constraints that limit a household's migration, then the SEM model is less applicable. Yet, as shown by the outflow of people from low-income coal communities, people do respond to local economic/quality-of-life conditions (Partridge 2010).

Population growth is theoretically an excellent metric to measure community success in a country with relatively high medium-term to long-term geographical mobility, such as the United States (Partridge 2010). People "vote with their feet" and move to places in which they expect will provide more satisfaction (or utility) as assessed by the individual's preferences. Individuals weigh some combination of quality-of-life or their economic well-being in making their determination. Another positive feature about population growth is that the researcher does not have to develop their own criteria for success, but through the revealed preference of actors, they will move towards places that are *expected* to provide more satisfaction or utility (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 states in the Midwest to relatively lower-income Sunbelt states because of warm winters (Partridge 2010). Roughly, people are trading off lower incomes to have a higher quality-of-life, or alternatively, to live in the dreary, cloudy Northeast and eastern Midwest, Americans need a compensating differential.

If economic actors are making rational decisions consistent with an underlying utility function, then the transitivity property must hold across all potential migration options—e.g., if Georgia is preferred to North Carolina in terms of net migration and North Carolina is preferred to New York in terms of net migration, then Georgia is also preferred to New York in terms of net migration. See Faggian et al.'s (2012) review of the literature describing empirical studies that appraise whether the transitivity property holds in U.S. migration decisions. They report that 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.

4.1.2 Supply-chain and other related effects.

Basic Input-Output Effects. When assessing an expansion or contraction of an industry such as coal mining, one of the most common applied models are "input-out" (IO) models, which are commonly used by practitioners for estimating economic development impacts. In IO models, there are three key effects starting with the direct effects of the additional output, value added, and employment in the coal industry (along with other economic outcomes). For example, if the coal industry increases employment by 100 workers and output by 3 million short tons, the <u>direct effects</u> are simply 100 jobs and 3 million tons. There are then <u>indirect economic effects</u> 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. Third, there are induced economic effects from the purchases of the workers that have been hired in the direct and indirect effects, such as for groceries and other household goods. The total effects is the sum of the direct, indirect, and induced effects.[19] To be sure, one does not need an IO models to estimate multipliers, but they have advantages of being well known by policymakers and they clearly decompose the responses outside of the direct industry.

The total economic multiplier is then defined as the (direct effect + indirect effect + induced effect)/(direct effect). It is simply 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 is a *gross* effect and their other (usually) offsetting negative employment effects. There are also corresponding multipliers for other economic outcomes such as output and value added.

Inaccuracies in IO Model Estimates. 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 of coal mining, further leading to IO models producing overestimates of economic impacts.

Probably the main factor working for IO models to *underestimate* multiplier effects are agglomeration economies. For example, feedback loops between customers and suppliers can create agglomeration economies that lead to positive feedback linkages the increase the size of economic impacts. The best examples are found in the New Economic Geography (NEG) (e.g.,

[19]The total effects are sometimes referred to as "type SAM," in which SAM is "Social Accounting Matrix. For details, see the discussion by Joe Demski of the IMPLAN economic impact software company, available at: https://blog.implan.com/understanding-implan-multipliers downloaded on June 26, 2020.

Krugman 1991).[20] Yet, even in NEG models, congestion effects eventually limit the size of a city as it becomes crowded, longer commutes, pollution, etc.

Other basic shortcomings of IO models are unavoidable. For one, the underlying coefficients such as IO technical coefficients that show how much of 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 way is to survey local businesses regarding their production technologies and purchasing decisions. While survey approaches capture local production idiosyncrasies, it still has measurement error and is 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 of local 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 be about 1.3 to 2 level for county-level economic impacts (e.g., Tsvetkova and Partridge 2016), which 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. In the case of the coal industry, one key input is the heavy coal-mining equipment. It is typically manufactured throughout the world. Such heavy-mining equipment manufacturing is typically not found in remote sparsely populated areas such as central Appalachia or the PRB—e.g., Caterpillar's main manufacturing site is Peoria, IL. In the U.S., the big heavy equipment that extracts and transports coal around the mining site is manufactured by the Construction Machinery Manufacturing industry (NAICS

[20]NEG models typically have traded-good firms with internal economies of scale and customers who desire a greater variety of consumption goods. More people in a given location implies more demand for products, which allows firms to increase production, further reducing input prices as firms gain economies of scale. Lower input prices allows firms to export even more, attracting both more people and more firms that further increase product variety, continuing the feedback loop. See Krugman (1991) for a discussion.

333120) for which coal mining is just a sliver of its output. U.S. Construction Machinery Equipment employment totaled only 72,000 workers in 2019.[21]

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.[22] There are other industries that supply inputs for coal mining, but they all employ limited 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.[23] 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.[24]

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 falling prices of alternative electricity sources such as 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 face environmental problems, leading to wide-scale closures of older coal power plants. The outcome has been a precipitous decline in fossil-fuel power-plant employment from 137,000 in 2009 to 82,000 a decade later.[25] Much of these job losses is simple efficiency gains from reallocating from ancient to modern technology. Some job losses may also relate to the nature of alternative energy in that its employment is not concentrated at traditional power plants. Nonetheless, reallocating away from coal-electricity power generation to other sources would likely have intangible effects on U.S. employment because the jobs lost in the coal-electricity supply chains would be offset to some degree by employment gains in natural gas-electricity supply chain and in alternative energy.

Case Study, Coal-mining multipliers in Virginia. To give a sense of the size of localized impacts on coal country from changes in coal mining employment, we examine the case of far

[21]Source: U.S. Department of Labor, *Quarterly Census of Employment and Wages*.
[22] Source: *Op. cit*.
[23] Source: op. cit.
[24] Source: op. cit.
[25] Source: op. cit.

southeast Virginia coal country.[26] Virginia has 7 counties that produce coal, all part of the ARC. The 3 main counties produce well over 80% of the coal. In order of their coal production: Buchanan, Wise, and Dickenson counties. Virginia's other 4 smaller-coal-producer counties include: Lee, Russell, Taxewell, and Scott Counties (Farren and Partridge, 2015).

Farren and Partridge (2015) analyzed the impact of the coal industry's impact 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 (see Table 1 for specific counties). Table 1 reproduces FP's table that reports the multipliers. Specifically, FP assessed the impact of a $1 million increase in coal production in 2011 on the three Virginia study regions. The table reports the direct effects from the initial increase in coal production, the indirect input supply-chain effects, and induced effects. Column (6) defines the total effect, summing direct, indirect, and induced effects. Finally column (7) shows the Social Accounting Matrix Multiplier (SAMM), which sums the three multiplier effects. Arithmetically, given the way FP defined their coal impact as an increase of $1 million in coal production, the total multiplier is the ratio of the total effect in column (5) to the direct effect in column (3). Henceforth, we will refer to the SAMM as the total multiplier.

Table 1 shows the expected patterns 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. The multipliers suggest 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. 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 based on respective output multipliers of 1.29 and 1.62. Note that the 7-county broader coal mining region has employment and output effects between the state and three-county core values. As noted above, the results likely overstate multipliers and that the estimates have statistical error.

[26] The discussion in this subsection draws heavily from Farren and Partridge (2015).

Table 1: Economic Impact of the Virginia Coal Industry*

IMPLAN Analysis of the Economic Impact of the Coal Industry by Region						
Analysis Region	**Analysis Type**	**Direct Effects[5]**	**Indirect Effects[6]**	**Induced Effects[7]**	**Total Effects[8]**	**Social Accounting Matrix Multiplier[9]**
Virginia (All counties)	Output[1]	1.0	0.347472	0.272133	1.619605	1.619605
	Employment[2]	2.45216	1.710638	2.205535	6.368333	2.59703
	Total Labor Income[3]	0.284314	0.113808	0.091317	0.489439	1.721473
	Employee Compensation[4]	0.200884	0.102938	0.081307	0.385128	1.917172
Coal Region (Buchanan, Wise, Dickenson, Lee, Russell, Tazewell, and Scott Counties)	Output[1]	1.0	0.237186	0.140119	1.377305	1.377305
	Employment[2]	2.459581	1.195366	1.183	4.837947	1.96698
	Total Labor Income[3]	0.282148	0.060486	0.035301	0.377936	1.339493
	Employee Compensation[4]	0.201501	0.055005	0.032066	0.288573	1.432116
Primary Coal Counties (Buchanan, Wise and Dickenson Counties)	Output[1]	1.0	0.178381	0.106756	1.285137	1.285137
	Employment[2]	2.45806	0.878107	0.941742	4.277908	1.74036
	Total Labor Income[3]	0.282592	0.052299	0.027636	0.362527	1.282864
	Employee Compensation[4]	0.201647	0.048233	0.026154	0.276034	1.368898

Note: See Appendix 2 for a discussion of the IMPLAN methodology.

Footnotes:

1 - Multiplying each Output-related "Effect" by $1,000,000 provides the estimated increase in production value correlated with a $1,000,000 increase in the value of coal production.

2 - The Employment-related "Effects" are measured in relation to an increase in the value of coal production of $1.0 million. For example, an increase in $1,000,000 in coal production in the Virginia analysis is correlated with 2.45 additional coal industry jobs, 1.71 additional jobs in industries supporting the coal industry, and 2.21 jobs in industries satisfying household demands for goods and services.

3 - Multiplying each Total Labor Income-related "Effect" by $1,000,000 provides the estimated impact on the total labor income (defined as the sum of employee compensation and proprietor income) correlated with a $1,000,000 increase in the value of coal production.

4 - Multiplying each Employee Compensation-related "Effect" by $1,000,000 provides the estimated impact on the total employee compensation (defined as the total payroll cost of the employee paid by the employer, including wages/salary, all benefits and all payroll taxes) correlated with a $1,000,000 increase in the value of coal production.

5 - "Direct Effects" represent the change in the industry under primary consideration – the increase or decrease in the monetary value of production, employment, etc.

6 - "Indirect Effects" represent the change in the industries which support the industry under primary consideration – as well as the changes in tertiary industries that support the secondary industries (and so on). The value listed is the total increase in the monetary value of production, employment, etc., for all indirect effects.

7 - The "Induced Effect" is defined as the change in economic activity due to the change in household consumption stimulated by changes in the wages/salaries paid to workers in the primary, secondary, tertiary, etc., industries.

8 - The "Total Effect" is simply the sum of the Direct, Indirect, and Induced Effects.

9 - The "Social Accounting Matrix Multiplier" is simply the ratio of the Total Effect to the Direct Effect. It measures the relative size of impact that a change in the primary industry has on the rest of the regional economy.

Source: IMPLAN Economic Impact Analysis Software (Data Year: 2011; Industry Code: 21 - Mining coal)

*Reproduced from FP, Table 2-3.

4.1.3 Description of statistical approach to identify success among candidate counties.

We now describe a simple *descriptive* regression we use to help identify counties that over- or underperformed in terms of population growth given the county's initial endowments. It seems reasonable that a "successful" transition away from coal would be one in which the location **overachieved** in terms of initial conditions. 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 of the ARC region, yielding a sample of 1,070 counties.[27] Adding the additional buffer counties provide more variation in outcomes and explanatory variables, and helps ensure we are not just considering a selected group of counties that are lagging by definition—i.e., the ARC was formed to address lagging development. Thus, we estimate the following simple regression model:

$$\Delta population_{t,t+j} = \alpha_0 + \alpha_1 Mining\ Employment\ Share_t + \alpha_2 (Mining\ Employment\ Share_t)^2 + \alpha_3 Population_t + Metropolitan_{1973} + NonAppalachian + Region\ ,$$

where *NonAppalachian* is an indicator equaling 1 if the county is in the 100-mile buffer zone outside of the ARC's region. *Region* is a vector of two indicator variables for different ARC regions. Population is the log of the initial-period population and Mining Employment Share is the share of the county's civilian labor force employed in mining. To be sure, mining 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. Mining share proxies for the importance or dependence the local county on the mining sector.[28] Appendix 1 provides the regression results and additional details of the regression model.

We anticipate that the 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).[29]

To provide perspective to our selection process, for the entire sample of 1,070 observations, the descriptive statistics in column (1) show that average population growth was 90.5% for the 1950-2018 period, falling to 30.5% between 1980-2018, and decreasing to 6.7% in the 2000-2018 period. Though not reported separately in the Table (though reported later), the average population growth rates for the 420 ARC counties are well below the sample average.

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[27] We do not extend the buffer farther, say to include the whole country, because that would introduce significant heterogeneity into the model.
[28] We caution that these regressions are descriptive, not causal.
[29]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.

The averages obscure some extremes. For example, McDowell County WV had the highest average 1950 mining employment share of 62% and a population loss of 82% between 1950-2018. In 1980, the highest mining employment share was in Martin County, KY at 46%, and it experienced a corresponding 19% 1980-2018 population loss. In 2000, the highest mining employment shares totaled 16% in Campbell County, TN, Martin County, KY, Mingo County WV, and Wyoming, County WV, with corresponding 2000-2018 population losses of 1%, 10%, 16%, and 19%. One pattern is that ARC economies concentrated in mining are associated with population loss, while the average U.S. county had substantial population gains.

4.1.4 Sample periods for analysis.

We tried dozens of regression models using different variable specifications over multiple time-periods to assess the best model fit and to determine whether the model results are robust. Our base model is population growth over the 1950 to 2018 period. We then examined population growth models, decade by decade, starting with 1950 to 1960 and finishing with 2010 to 2018. Not surprisingly, with the exception of the 1970s energy boom, every model produced a negative mining-share coefficient that was statistically significant.

After this initial evidence, we determined that outside of cases in which the locality began to transition away from coal in 1950, there was little value in examining models with 1960 or 1970 as the initial-starting period. The main reason is that the late 1960s through 1982 was a coal-boom era, marking an unlikely time period for the beginning of a successful transition away from coal. Thus, in addition to the 1950-2018 model, our focus was on the models over the 1980-1990, 1990-2000, 1980 to 2018, 1990 to 2018, 2000 to 2018, and 2010 to 2018 time periods.[30]

4.1.5 Identifying initial candidates for relative "success."

Before using the statistical results, we need to determine whether a county was initially dependent on mining of any sort (we will consider just coal mining below). To be considered as potential candidate for a successful transition from coal, **if the initial year was 1950, we set an 8% mining employment share threshold for whether the economy was initially mining dependent**. The ARC average 1950 mining share was 6.75% and the average for counties within 100 miles of the ARC was 0.8%. In 1950, there were 99 ARC counties that met our 8% mining-share criteria with an average mining share of 23.7%. Given that the ARC region was a coal-intensive/mining-intensive region in general, 99 out of 420 counties seems to be an excellent start at identifying potentially coal-dependent regions and **we will refer to these 99 residual cases many times below**.

After estimating the regression models, we ranked the residuals (error terms) from the highest to lowest for these 99 "mining-intensive county" observations. With 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 (e.g., 1950-2018, 1980-2018, etc.), we considered the top one-third of the mining-intensive counties in terms

[30] Further study suggested that the 1980-1990, 1990-2000, and 2010-2018 models are redundant with the longer-time period models, and not needed for in-depth analysis.

of their residuals (with the largest positive residuals) as potential candidates for successful transitions (or 33 cases for the 1950-2018 model).

We follow this regression procedure decade-by-decade and for cases over longer sample periods (e.g., 1980-2018), but given that coal mining's importance declined over time, we lower the bar to a 4.0% mining employment share threshold for 1980 and thereafter—i.e., to be in the pool of counties for success consideration, they need at least 4.0% mining employment share in the initial year beginning in 1980. Such a low initial mining share may strike some as 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, yielding smaller share values.[31] Also, as we describe below, while we cast a wide net for potential candidates for successful transition counties, there are very few cases of success. Overall, we identify 123 *additional* candidate counties that met the 4% mining share threshold.

4.1.6 "Over-performing" mining-intensive counties and long-term population growth.

Before proceeding, Figure 8 demonstrates why we expect very few successful transitions. Plotted is 1950-2016 population growth for 222 *candidate* counties identified in 1950 or 1980 as mining-intensive. So with a total 222 counties divided into six groups of 37 or 38 counties each. These include the 99 candidates using the 8% mining share threshold identified from 1950 and another 123 identified in 1980 using a 4% mining share threshold.

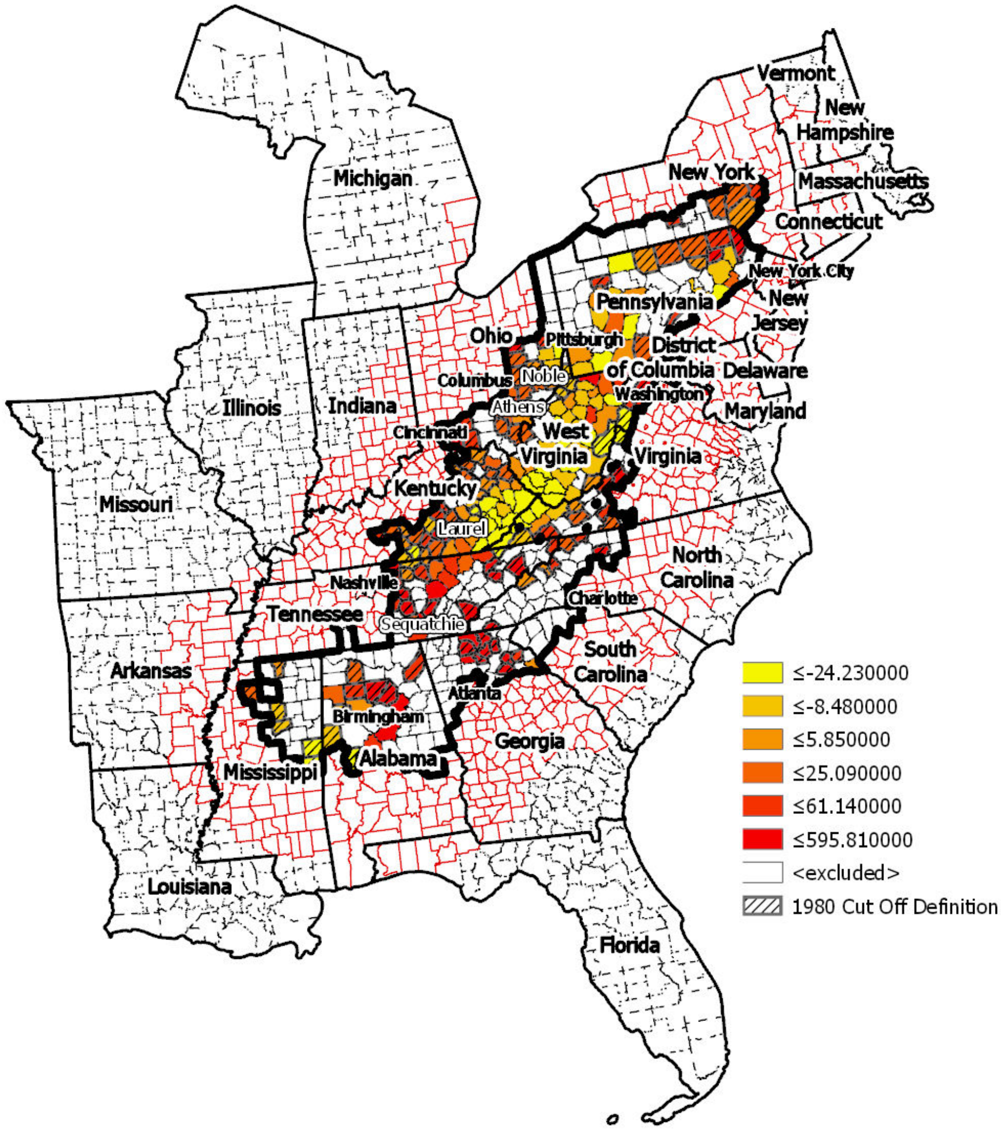
The six categories in Figure 8 are split into equal-sized groups for ease of comparison. Comparing the growth of the 222 candidates to the averages for the population growth shown at the bottom of Table 2 highlighted in red, are nonmetropolitan and metropolitan average 1950-2018 population growth rates for the U.S. and the ARC in the column labeled "%p5018." Overall, U.S. growth for all counties averaged 116% over the period versus an average of only 70% for ARC counties—i.e., ARC counties lagged the national average. Yet, the average population growth for the 222 mining-intensive counties is only 27%, and 95 of these counties lost population. Thus, even when using the slower ARC average growth rates as the benchmark, its average is over two-and-half times faster than the average ARC mining-intensive county.

Table 2 shows that the 1950-2018 ARC nonmetro county population growth averaged 45% and 1950-2018 ARC metro population growth averaged 177%. Among the 223 mining-intensive counties, only 28 nonmetro and 4 metro counties grew faster than their corresponding ARC average population growth (only 16 nonmetro and 6 metro counties grew faster than their corresponding U.S. average). Just 32 out of 222, or less than 15% of mining-intensive ARC counties, grew faster than their corresponding 1950-2018 ARC average population growth, which suggests that the pool of successful-transition candidates is limited.

Population growth is also spatially persistent, and if anything, the relative performance of the most coal-intensive areas in Central Appalachia lagged even farther behind after 1980, and especially after 2000. Appendix, Figures 13 and 14 present population growth maps for the 1980-2018 and the 2000-2018 periods, illustrating the persistent growth pattern.

[31]Between 1950 to 1980, U.S. coal mining employment fell 46% and the civilian labor force *rose* 72%.

Figure 8: 1950-2018: ARC %Population Growth in 1950 and 1980 Mining-Intensive Counties



Notes: The <u>non</u>-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. What's reported is the union of those two cases, or 222 counties.

4.1.7 Elimination of candidate counties.

For the potential 33 cases as determined by the largest positive residuals (error terms) for the 1950-2018 model, we eliminate 31 counties from consideration for the following reasons:

- We first checked if the mining taking place in 1950 was actually predominantly coal.[32] Using the 1954 *Census of Mining Industries*, this was typically the case. To be considered a coal county, we use the rule that at least two-thirds of its mining employment had to be coal. One feature is that many of the fast-growing counties in the mining-intensive group had dominant mining industries besides coal, including a handful of cases such as stone, mica, limestone, marble, and granite in a cluster of fast-growing North Georgia counties. Others had large oil and natural gas sectors. Shelby County, Alabama (Birmingham, AL metropolitan area) grew rapidly between 1950-2018 period. It had a large coal mining industry in 1950, but also a large ore mining industry (i.e., coal was below two-thirds of mining employment). In such cases, those counties were eliminated for now.

- The second criteria is that depending on whether the mining-intensive county was metropolitan or nonmetropolitan, the county had to exceed the ARC region's total metropolitan or nonmetropolitan average population growth rate during at least one period.[33] The periods considered were 1950-2018, 1980-2018, 2000-2018, 1980-1990, 1990-2000, and 2000-2010.

- The third criteria is that the county had to go through a sustained period entirely without a coal mining industry, or at least an industry that was an insignificant part of the county's economy. We define a coal employment share of the labor force of less than 2% as the threshold for no longer having coal-mining dependence. In a relatively populated Appalachian mining county, that would be one typical mine, and for a small ARC county, that would be one small coal mine. Thus, we checked coal employment in 1980, 1990, 2000, 2010, and 2016 to assess whether our criteria ever held. There are a handful of cases in which the county switched from being heavily coal to oil & gas dependent, especially in the last 15 years. Yet, switching from an environmentally problematic boom/bust industry subject to the natural resource curse to another is far from building a healthy sustainable local economy that is diversified from economic risk and climate-change regulation. So, we eliminated those handful of cases.

- Using the 31 candidates that failed those criteria, we also examined whether counties that were not included would have met these criteria for 1980, 1990, 2000, 2010, and 2016. In particular, if the county never grew faster the ARC average, there would be no need to

[32] There are no publically-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. Thus, we can identify whether they exceeded the 2% coal mining employment share threshold.

[33] We use the 1973 metropolitan definition given it is in the middle of sample period, and as noted when discussing the regression analysis, it fits the data better.

check further. Likewise, if the county had a coal industry in every period, and never transitioned away from coal, there would be no need for further analysis. Yet, the case in which these 31 counties could still be identified as successful coal-mining transition cases occurs when the county had other mining industries (i.e., it crossed the 1950 8% mining share threshold) but its 1950 coal industry was insufficiently large. In that case, we check whether the county ever had a sufficiently dominant coal industry in 1980, 1990, 2000, and 2016. If so, and it met the other criteria, the county would be included as a successful transition county. Likewise, we went through the same process for the 39 counties that eventually failed in the 1980-2018 case, as well as other failed cases from later periods.

- Turning to the 1980-2018 and assessing the additional 41 counties (one-third of the 123 added counties identified as mining dependent) that were identified from the 1980-2018 regression residuals, not including the 33 possible cases from 1950 (which we had already checked as described above). We then assess whether these 41 candidates met the above criteria (only 2 new counties met the criteria). For the 39 counties that failed the criteria, we then checked whether they fully met the criteria when checking later periods—i.e., 1990, 2000, and 2010.

- We then considered 1990-2000 and 2000-2018 regression model residuals and separately ranked the top one-third of those residuals for both models and using the 4% mining-share threshold for potential candidates. After eliminating any overlap among counties that were either one of the 33 potential candidates from 1950-2018 and 41 from the 1980-2018 model, we re-did the same process for 1990-2018, 2000-2018, and 2010-2018 model residuals to assess whether any of those candidates met the successful transition county criteria. However, by the time we reached the 1990-2000 period, there were already very few new candidates that had not already considered because: (1) they were either considered from the 1950-2018 case or they were considered from the 1980-2018 case, or (2) as average mining shares tumbled over time, this meant that fewer counties met the 4% mining threshold over time, or (3) they did not over-perform in any of the regression sample periods.

At the end of this labor-intensive process, only 4 counties were selected as successful coal transition counties, even using the relatively loose criteria we used. In order of success:

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

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

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

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

Figure 8 lists the four successful-transition counties on the map and Appendix 1, Figures 3-9 also map the counties, as well as indicates coal-mining intensity in 1954. Note that Sequatchie County has fully transitioned away from coal and Athens County also appears to have fully transitioned away from coal.[34] The last coal employment in Athens County was in 2014 with 2 miners, and it was very small beforehand. Laurel County's coal industry peaked in the early 1980s and mostly closed by the early 1990s. There remains a very small operation with about 10 employees. Since the late 1980s, Noble County also has had small coal operations that employ 40-50 workers with a 2018 payroll of $2.8 million. We deem this as so small that Noble County is no longer coal dependent (though, Noble County is the weakest case among the "successful" coal-transition cases due to its weak performance).

4.2 Other Outcome Measures for Successful ARC Coal Transition Counties vs. High-, Median-, and Poor-Performing (1950) ARC Mining-Intensive Communities.

We now make comparisons across key indicators often associated with well-being by the public or policymakers for different types of mining communities including our four successful transition communities. So what follows is a range of comparisons to gauge a successful transition and how do such counties compare to other mining-intensive counties. With only four successful coal transition counties, it is impractical to do standard statistical analysis, but we assess the underlying "success" factors using descriptive analysis.

4.2.1 Creating different reference groups for comparison to selected successful counties.

Our reference counties are three separate groupings of 10 mining-intensive counties. We use the 1950-2018 model's 99 regression residuals to determine the included counties. We select that model because it indicates long-run success and we have already shown strong spatial persistence in population growth over the 1950-2018 period and shorter sub-periods such as 1980-2018 and 2000-2018. The first category includes the four relatively successful coal-transition counties from above. Then we include 10 high-, 10 median-, and 10 poor-performing mining counties from ranking of the 99 residuals (error terms) we used above from the 1950-2018 population growth models. The 10 high-performers are the 10 highest-residual counties, net of the successful coal-transition counties. These ten counties represent "stronger-performing" mining-intensive counties given their initial 1950 conditions. Median- and "weak-performing" mining counties are respectively the middle 10 counties among the 99 ranked residuals and lowest-10 residuals. The median 10 represent counties that reflect the expected performance, whereas the bottom 10 represent counties that most underperformed given their initial

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[34] 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.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwiu8pKe4aHpAhVFKqwKHS5eA4YQFjAAegQIAhAB&url=https%3A%2F%2Fwww.msha.gov%2Fsites%2Fdefault%2Ffiles%2FData_Reports%2FCharts%2FCoal_Employment_by_State_and_County_CY09to15.pdf&usg=AOvVaw0fcxcFl1DDje5pe48TPmwY. Accessed May 7, 2020.)

characteristics. Thus, we can compare our relatively successful transitions away from ***coal*** mining counties to successful "overperforming" ***mining-intensive*** transition counties, average mining-intensive transition counties, and unsuccessful "underperforming" mining-intensive counties. Bear in mind that over the entire period, and even today, coal remains the dominant ARC mining industry and that "mining-intensive" typically means coal.

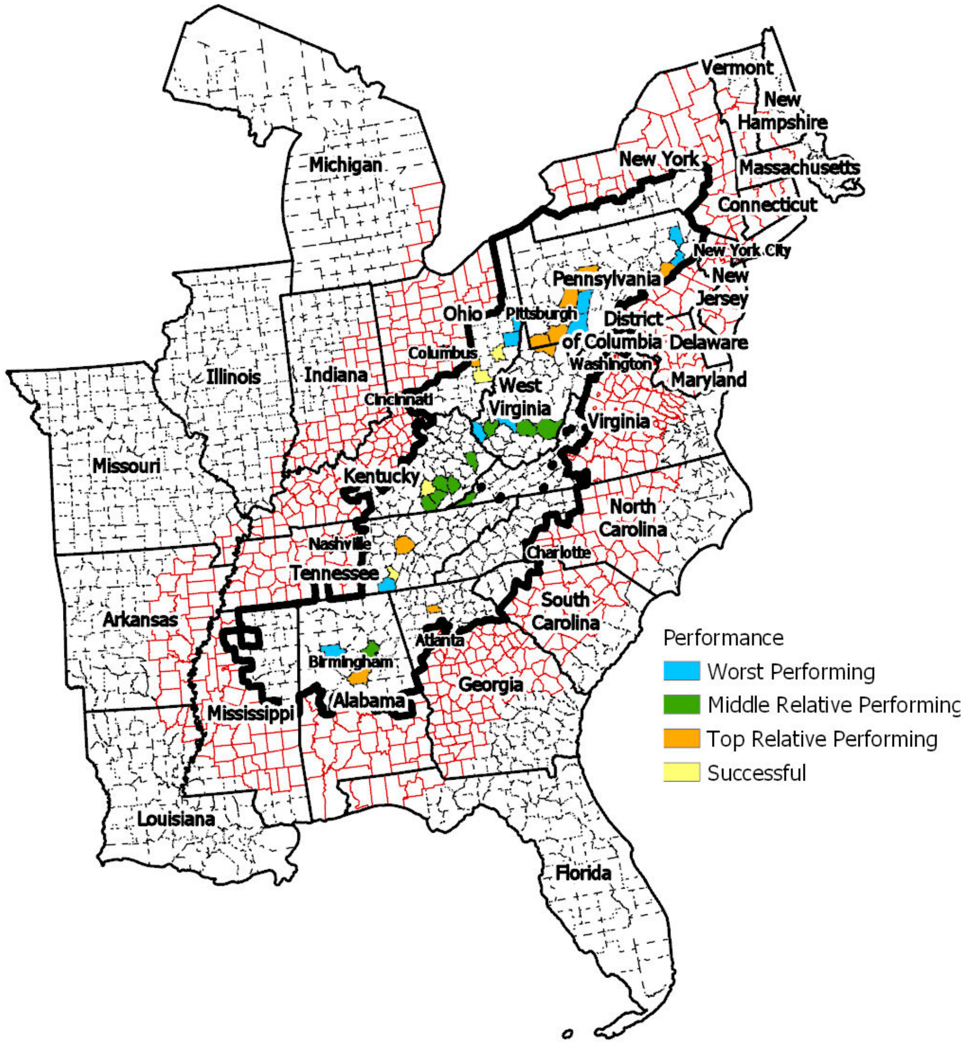
Figure 9 shows the location of the four relatively successful transition counties and the three high, median, and poor-performing mining-intensive counties. The map's color scheme is the same as the tables below—e.g., yellow on the map corresponds to the yellow highlighting of the successful transitions counties on Tables 2-6. What is apparent is that the geographical distribution of low-, median-, and high-performing counties is quite dispersed across the ARC, suggesting no systematic geographical issue in their selection.

Table 2 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 definitions), all U.S. nonmetro counties, all ARC metropolitan counties (1973 definitions), and all ARC nonmetro counties (some cases do not have U.S. averages if unnecessary). 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.

Table 2 below shows that among the four coal-transition relative success stories, only Sequatchie County, TN is a metropolitan county—i.e., part of the Chattanooga, TN metropolitan area since 1973. Thus, urban-led growth is not the reason for the other three counties to have more successfully transitioned.

Table 2 also shows that Sequatchie and Laurel Counties had relatively rapid population growth. Laurel County's growth roughly tripled the nonmetropolitan average ARC population growth rate between 1950-2018, while Sequatchie County slightly trailed the average ARC metropolitan rate. Yet, recall that the 99 mining-intensive counties greatly trailed the other ARC counties in terms of average population growth—i.e., a mining-intensive county slightly trailing the ARC average is relatively good given its initial conditions. Laurel County population growth exceeded the ARC average during every period. Sequatchie's County's growth rate exceeded the ARC metropolitan average in the 1970s, but it was not until the 1990s that it was consistently above the ARC average.

Figure 9: Successful Transition and Low-, Median-, and High-Relative Performing Counties



Notes: The location of the comparison groups in Tables 2-6. Yellow is the four successful-transition coal mining counties, blue is for the relatively worst-performing mining-intensive counties, green is for the median-performing mining-intensive counties, and orange is for the higher-performing mining-intensive counties.

Laurel County was an intermittent coal producer with heavy production between 1940-1960 and 1970-1988, after which Laurel County's coal production was quite small. We deem it transitioned away from coal dependence around 1990.[35] Sequatchie's coal dependence ended in the mid-1980s as the resident share employed in mining declined. The probable causes likely include the 1980s coal bust and enhanced economic diversification as it became integrated with Chattanooga. Both counties appeared to experience relatively rapid growth while they were still coal dependent. In sum, they successfully transitioned away from coal by the early 1990s and they were achieving success before large-scale coal production ceased.

Athens County, Ohio is the third relatively successful coal transition county. Its average growth rate was slightly below the ARC's 1950-2018 nonmetro average. Its growth rate exceeded the ARC average in four of the seven decade periods, and between 2000-2010, its 3.8% population growth fell between the U.S. nonmetropolitan average of 3.5% and the ARC's average of 4.5%. While not booming, Athens County has had steady growth. It had a moderate-sized coal industry in the 1950s, but after the early 1960s, its coal industry was very small, totally disappearing after 2009—i.e., it appears to be the first county to successfully transition away from coal.

Now turning to the fourth relatively successful coal-transition county, Noble County, Ohio. Table 2 shows that Noble County generally underperformed the ARC nonmetro average population growth during the 1950-2018 period. Its inclusion in the success list was because it greatly over-performed the ARC average in the 1990s. In addition, during the 2000-2010 period, Noble County's 4.2% population growth fell between the U.S. nonmetro average of 3.5% and the ARC nonmetro average of 4.5%, as shown by the grey cross hatches for that case.

Noble County still has a small coal mining sector. Various years of the *Census of Mineral Industries* and *Ohio Mineral Reports* indicate that since the mid to late 1970s, its coal industry has employed about 40-60 workers. It is also intermediately home to a small oil and gas industry during high-drilling periods. Having more intensive-coal mining neighbors such as Belmont County, Ohio to the northeast means that Noble County is home to residents who commute elsewhere to work in mining (mainly oil and gas, and coal). Together, this explains how Noble county's place-of-residence mining employment share is higher than what would be anticipated given it small local mining/coal employment. In sum, while we include it as a "successful" case of transitioning away from coal, it is a marginal example.

After the energy bust in the early 1980s, Noble County was less exposed to the energy industry (coal in particular). Thus, it appears to have made its successful transition away from coal about a decade before its relative prosperity of the 1990s and early 2000s. Nonetheless, Noble County did not fare well after the Great Recession.

In comparison to the other groups, the four successful transition counties experienced much faster average population growth than the 10 median performing mining-intensive counties (after accounting for their basic factors) and especially the 10 worst under-performing counties, which had a negative average population growth rate between 1950 to 2018. Yet, the successful counties modestly trailed the over-performing mining-intensive counties between 1950-2018, but

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

the over-performing county average is distorted by particularly rapid growth in Shelby County, which is part of the Birmingham metropolitan area and Pickens County, GA, which has experienced rapid amenity-led growth. To be sure, since 1990, the four "successful" transition counties have experienced slightly faster average growth than the over-performing mining-intensive counties, illustrating that the benefits of transitioning away from coal may be paying off. It is also the case that the relatively successful transition counties greatly exceeded the median performing mining-intensive counties and especially the weakest under-performing counties, which have generally lost population since 1980. Overall, the relatively successful coal transition counties are doing better than most over-performing mining-intensive locations since 1990, and they are growing much faster than those in the middle or bottom, showing that after eliminating over 98% of the potentially successful mining-intensive counties candidates, the four selected ones are *relatively* quite successful.

Table 3 presents mining-employment shares for each decade spanning 1950 to 2010, along with the 2016 mining employment and coal-mining employment shares. 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*.

The dynamic mining employment pattern was described above. Its share falls from 1950 to 1970, then rising until 1980, before falling thereafter. The relatively successful-transition counties have above average mining shares compared to the ARC region until 1990, after which their shares fall below the ARC average, illustrating that they no longer depend on coal mining. The relatively over-performing mining-intensive counties tend to have higher mining shares than the relatively successful-coal transition counties (except 1980), though the gap is quite small after 1980. Not surprisingly, industry diversification away from mining is associated with economic prosperity—though over-performers are somewhat skewed because 5 of the 10 counties are 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 over-performing mining-intensive counties, after which their mining shares converged.

The weakest-performing mining-intensive counties had a rather surprising pattern. Their mining-share had converged to relatively successful transition counties by 1970. Afterwards their mining share typically was either equal or even below the four successful transition counties. One possible reason is that the underperformers are often metropolitan counties that had both coal and complementary manufacturing in the middle 20^{th} century—e.g., integrated steel mills. After these manufacturing industries imploded due to foreign competition and technological change (e.g., shifting away from integrated steel mills to mini-mills), the impetus for these small industrial cities no longer existed, leading to depopulation and declining coal demand.

Table 2: Successful and Selected Counties %Population Growth Rate 1950-2018

County	State	Table 2:	A73	MSA13	%Δp5018	%Δp5060	%Δp6070	%Δp7080	%Δp8090	%Δp9000	%Δp0010	%Δp1018
Successful Coal Transition Counties												
NOBLE	Ohio	39121	0	0	22.9	-6.5	-5.0	8.5	0.2	24.0	4.2	-1.4
SEQUATCHIE	Tennessee	47153	1	1	133.9	-3.9	7.0	35.9	3.0	28.3	4.2	3.9
LAUREL	Kentucky	21125	0	0	133.3	-3.5	10.0	42.3	11.4	21.4	11.7	2.2
ATHENS	Ohio	39009	0	0	43.8	2.5	16.8	2.8	5.6	4.5	3.8	2.1
Average					89.8	-0.9	7.2	22.4	5.1	19.5	3.8	1.7
Std Dev					66.5	5.0	9.1	19.7	4.8	10.4	9.8	2.2
Top Relative 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					107.9	-5.0	2.0	20.8	7.2	16.5	9.0	1.1
Std Dev					197.9	6.6	10.3	21.5	18.7	21.5	15.4	5.1
Middle 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

Table 2: Successful and Selected Counties %Population Growth Rate 1950-2018 – Cont.

County	State	FIPS	MSA73	MSA13	%Δp5018	%Δp5060	%Δp6070	%Δp7080	%Δp8090	%Δp9000	%Δp0010	%Δp1018
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
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. The individual categories are the four relatively successful coal-transition counties. The higher-, median-, and lower-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 poor-underperforming mining counties.

2. 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.

Table 3: Successful and Selected Counties Mining/Coal Employment Share 1950-2016

County	State	FIPS	MSA73	MSA13	MSH50	MSH60	MSH70	MSH80	MSH90	MSH00	MSH10	MSH16	COAL16
Successful Coal Transition Counties													
NOBLE	Ohio	39121	0	0	9.9	5.2	9.9	17.7	7.8	2.9	1.3	0.5	0.7
SEQUATCHIE	Tennessee	47153	1	1	15.8	5.4	6.3	7.8	1.5	0.5	0.0	0.0	0.0
LAUREL	Kentucky	21125	0	0	5.8	1.8	0.9	9.9	2.8	0.8	3.2	0.8	0.8
ATHENS	Ohio	39009	0	0	11.6	2.4	0.7	5.0	1.7	0.6	0.5	0.0	0.0
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
Top Relative 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
Middle 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

Table 3: Successful and Selected Counties Mining/Coal Employment Share 1950-2016 – Cont.

County	State	FIPS	MSA73	MSA13	MSH50	MSH60	MSH70	MSH80	MSH90	MSH00	MSH10	MSH16	COAL16
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
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

Notes: 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 poor-underperforming mining counties.

Table 4 reports median household income (average family income for 1950 is used due to data availability). In 1960, median household income in relatively successful coal-transition counties averaged 82.6% of over-performing mining counties, rising to 84.3% in 1990, before slightly declining to 83.9% in 2018. Thus, there is no clear trend, though this is not an apples and oranges comparison. High-performing mining-intensive counties are more populated and the disamenities of coal mining may require compensating differentials for local residents. Thus, a better appraisal compares relatively successful-transition counties 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, falling to 23.3% in 1990, and stabilizing at 22.8% higher in 2018. While successful-transition coal counties had higher median-household income over the entire period, the median-performing counties made relative gains over time. As noted before, median-performing counties were losing population unlike relatively successful coal-transition counties. Thus, this income pattern appears to reflect the effects of falling labor supply in median-performing counties to reestablish equilibrium and is not a reflection of a relative improvement in local well-being that attracts migrants.

In 1960, successful-coal transition counties had a median household income 73.6% of the poorest performers. By 1990, the ratio had increased to 89% and to 94.8% in 2018. Overall, successful transition counties had made impressive gains in median household income compared to the poorest performers. Given that poorest-performers were hemorrhaging population faster than median-performers, 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 by the SEM discussion above, these patterns are unsurprising because average income shows no clear trend due to regional compensating differentials.

Table 5 shows poverty rates from 1960 to 2018, revealing some surprising patterns. In terms of their levels, median-performing counties had remarkably high average poverty rates in 1960, with the average being 20 percentage points above that of the four relatively successful-transition counties, which at 44.1%, was already alarmingly high. The highest-performing and poorest-performing mining-intensive counties also had high poverty rates, but less than the successful-transition counties, with poverty rates respectively averaging 35.6% and 29.8%. The median-performing counties had a 1960 poverty rate averaging 61%. Yet, illustrating extreme poverty of Appalachian mining-intensive regions, the 1960 overall U.S. poverty rate was only 22.2%. It is not surprising that Congress enacted the ARC to address longstanding persistent poverty in 1965.

Between 1960 and 1980, Appalachia made remarkable progress on poverty. In 1980, the average ARC metropolitan county poverty rate averaged 12.7% (vs. 30.4% in 1960) and the nonmetro county poverty rate averaged 19.1% (vs. 45.9% in 1960). The overall 1980 U.S. person rate equaled 13%. After 1980, related to rising overall U.S. income inequality, further gains in reducing poverty stagnated (the ARC region actually lost ground).

Regarding the four comparison groups, they all experienced average poverty declines from 1960 to 1980 and increased poverty rates between 1980 and 2018. Between 1960 and 1980, the relatively successful-coal transition, highest-performing, median-performing, lowest performing counties experienced average poverty rate declines of 24.6, 21.2, 35.1, and 17.7 percentage points, respectively. Between 1980-2018, the corresponding *increases* in poverty rates totaled 2.1, 0.6, 0.5, and 1.8 percentage points. The relatively weakest-performing counties turned in the worst performance between 1960-2018, and all categories experienced stagnation after 1980.

Table 4: Successful and Selected Counties (Nominal) Median 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
Top 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
Top Ten Middle 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
Top 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: 1. 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.

Table 5: Successful and Selected Counties 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
Top 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
Top Ten Middle 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
Top 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.

5. FACTORS RELATED TO PROSPERITY/POVERTY ACROSS COAL TRANSITION COUNTIES: QUANTITIVE FINDINGS

In this section, research question three is addressed: What factors matter for Appalachian communities that relatively more successfully transitioned away from coal? Here we report the results of analyses based on quantitative data for Appalachian counties.

5.1 Examination of Sources of Local Growth.

The data we have not yet considered are the factors that social scientists typically associate with affecting local economic development. In what follows is an appraisal of the factors that might have promoted the relative success of the four relatively successful counties that transitioned from coal. The presentation remains descriptive using similar tables as used in Section 4.

5.1.1 Population and local economic growth.

One of the key factors in understanding economic development in lagging U.S. regions is the lack of access to urban areas and an insufficient population for a critical mass of producer and consumer services that support growth (agglomeration economies). To understand whether urbanization underlies why our successful transition counties fare well, we consider their population levels in Table 6. The relatively successful coal transition counties are sparsely populated with a 2018 average population of 38,800. The median-performing counties are likewise small with an average 2018 population of about 34,800. Surprisingly, the relatively top-performing and weak-performing mining-intensive counties are more populated with an average 2018 population of over 90,000. That pattern is unexpected given the standard urban-economics hypothesis that agglomeration economies are a major determinant of local economic growth. The finding is encouraging because relatively unpopulated coal-mining communities can transition away from coal without devastating economic consequences.

5.1.2 Human capital and local economic development success.

Table 7 shows the average share of the population over 25 years old with at least a Bachelor's degree (CG), some college including an Associate degree (SC), and high school graduates (HS) for 1950, 1980, 2000, and 2018. The four relatively successful coal mining transition counties had average educational attainment that is skewed upward by the relatively strong performance of Athens County, home of Ohio University. In the other three successful transition counties, educational attainment is generally low, especially for the college graduate share. Yet, such skewness also applies to the highest-performing mining-intensive counties. For example, Monongalia County, home to West Virginia University in Morgantown significantly increases that category's average education.

Comparing the four relatively successful transition counties to the other categories, it is apparent that they slightly trail the most-successful mining-intensive counties on average in terms of human capital, especially for recent levels of college graduates. Yet, these four counties exceeded median-performing and low-performing mining-intensive counties, as well as the nonmetropolitan ARC average.

Table 6: Successful and Selected Counties' Population 1950-2018

County	State	MSA73	MSA13	Pop1950	Pop1960	Pop1970	Pop1980	Pop1990	Pop2000	Pop2010	Pop2018
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
Top 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
Top Ten Middle 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
Top 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: 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.

Table 7: Successful and Selected Counties' Human Capital Share (% of population > 25 yrs 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
Top 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
Top Ten Middle 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
Top 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: 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.
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.

In sum, the four relatively successful counties had above-average education compared to the typical ARC nonmetropolitan county throughout the 1950-2018 period, which may partially explain their relative success. Yet, as noted above, among the four relatively successful transition counties, only Athens County particularly excelled in terms of human capital and that is due to significant state investments that are hard to replicate in general. The other three counties generally had average education below all of the other groupings except for having about the same as the median-performing mining-intensive counties. Thus, we conclude that educational attainment in itself does not underlie why the other three counties had relative success in transitioning away from coal.

5.1.3 Industry composition and local economic success.

Table 8 reports some indicators for key industries to appraise whether there any key industry composition patterns that may explain the relative success of the four relatively successful coal transition counties. The selected four time periods are the same as Table 7.

The first is agriculture, reported as the county's share of residential total employment. *A priori,* farming should have mixed economic effects. On the positive side, agriculture cannot be offshored to Asia and can be a source of new entrepreneurship. However, labor-saving productivity change over time has meant that fewer farmers produce more food. For example, farming's share of total U.S. employment was 41% in 1900, 21.5% in 1930, 4% in 1970, 1.9% in 2000, and just over 1% in 2019 (U.S. BLS; Dimitri et al. 2005). Thus, heavy reliance on farming in itself would not offset declining coal mining employment.

Table 8 shows that the successful four transition counties all had relatively large average shares of agriculture employment in 1950, averaging 32%, which is larger than the 1950 ARC nonmetro farm share and considerably greater than the averages for the other three mining-intensive groups. The weakest-performing mining-intensive group had the lowest 1950 average farm share, which totaled only 8%. While it is unclear whether higher 1950 agricultural-intensity helps causally explain the eventual success of the four successful transition counties, it is an interesting pattern. To be sure, following the national trend, average farm employment shares fell in all four mining categories after 1950, becoming relatively insignificant today.

The second industry is the county's share of employed residents in manufacturing. Given its relatively high compensation, manufacturing has long been thought to be a key step in the rural development process, especially in the mid-20th century. In fact, U.S. BEA data indicates that beginning in the mid-1970s, rural manufacturing grew relatively faster than in metropolitan areas and had a higher share of manufacturing employment thereafter.

Table 8 shows that the four relatively successful counties had a much lower average 1950 manufacturing employment share than the other three mining-intensive categories, equaling 11%, which was slightly less than the average U.S. share. Yet, after 1950, their manufacturing relatively exploded, peaking in the 1980 to 2000 period, while the U.S. was deindustrializing through the period. The main exception among these four "successful" counties is Athens County, OH, in which the presence of Ohio University plays a unique role. The other three mining-intensive categories generally experienced a relative decline in manufacturing shares.

Table 8: Successful and Selected Counties' Industry 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
Top 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
Top Ten Middle 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
Top 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

Sources: Industry composition and self-employment data is from U.S. Census Bureau, Decennial Census of Population.
Notes: AG: Agricultural (including fishing, hunting) employment share; MF: Manufacture employment share; SE: Self-employment share, all measured by place of residence.
*the national average—i.e., not the national average across counties.
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

after 1950, mirroring national patterns. Yet, after 2000, manufacturing intensity in the four successful transition cases greatly decreased, converging to the other three mining-intensive groupings and to the U.S.

These manufacturing patterns indicate that it is possible that in three of the four successful transition cases (except Athens County), the rapid industrialization between 1950 and 2000 may have played a reason for their relative success, especially given that U.S. manufacturing generally struggled. However, it is hard to see how this pattern could be replicated 40-plus years later. Manufacturing's U.S. employment share is about one-third of what it was in 1950 and rapid productivity growth, pressures to offshore input production, and fierce global competition means that U.S. manufacturing faces strong headwinds.

Talk of manufacturing "reshoring" due to changes in global trade seems unrealistic because it is unlikely firms will shift production from (say) China to U.S. when other low-wage countries like Vietnam remain attractive. Likewise, while Covid-19 is currently an agonizing event, it is unlikely to realign significantly more manufacturing to the U.S. Namely, concentrating more manufacturing in the U.S. places American firms at a disadvantage if the U.S. faces a natural disaster, pandemic, or global trade disruptions that affect its exchange rates or supply chains. Diversifying the international supply chain still has its advantages, though it is quite possible that for certain "national security" cases, manufacturing will reshore to the U.S. The point is that hoping that manufacturing can replace coal-mining going forward is risky, and that is even before considering the general remoteness from suppliers and customers that would face Appalachian coal-country manufacturers.

The third industry indicator reported in Table 8 is the share of employed residents that is self-employed.[36] Higher self-employment intensities are associated with faster subsequent economic growth, larger multiplier effects through locally-based supply chains, and profits remaining local, all of which support faster local growth (Stephens and Partridge 2011; Stephens et al. 2013; Tsvetkova et al. 2019). The ensuing increase in local entrepreneurship is a positive force that can make local communities more resilient to economic change such as restructuring in historic industries such as coal mining. Stephens and Partridge (2011) particular find that greater shares of self-employment support faster growth in the ARC region.

As was the case for farming, Table 8 shows that the four relatively successful coal-mining transition counties have quite high self-employment intensities, averaging 33% in 1950. Athens County, given its unique nature, had a 1950 nonfarm self-employment share of only 19.6%, which is well below the other three relatively successful coal-transition counties. Relative to the other three mining-intensive categories, the four successful coal transition counties had above average self-employment rates throughout the period, though their advantage declined over time.

Like agriculture, relatively high self-employment rates in the 1950-1980 could have given the "successful" transition counties an advantage in terms of more local entrepreneurship and

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[36]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 publically traded on financial markets.

resilience when coal mining faded. While this pattern is only suggestive given the small sample size, it does point to the potential of using local assets and capacity to forge local small-business development as a way to counteract declining coal mining employment—meaning that coal-country policymakers should invest in small business development.

5.1.4 Age structure, dependency ratio, and local growth.

The age structure of a locale can affect its subsequent growth. In particular, the dependency ratio—i.e., the share of "children" and "senior citizens" that are at least partially dependent on local government for education or for senior services including healthcare. Yet, a larger share of children can support future growth if they remain after their schooling and join the local labor force. Likewise, while a greater share of senior population may increase the local fiscal burden in terms of greater social and health spending, if the location is a retirement destination such as Arizona, the far south Atlantic states and Gulf Coast states, it can lift local economies when they attract sufficient numbers retirees, especially wealthy retirees. Nonetheless, for most if not all of the period under consideration, Appalachia coal-country was not premier retirement destination for wealthy retirees that offset fiscal burden. It is less than clear if this can change in the near- to medium-term, though a clean environment would be necessary.

Table 9 shows the share of the population under 18 years old (under 20 for 1950) and the share of the population over 65. What stands out is that the four relatively successful coal-mining transition counties are not much different than the three other mining-intensive categories or from the broader ARC region or U.S. Thus, we conclude that their relative success in transitioning away from coal is not due to demographic-age structures.

5.1.5 Geographical and demographic characteristics and local growth.

There are several other geographical characteristics that can affect local economic growth. Table 10 reports several in turn. First, 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 in terms (Partridge and Rickman 2008; Partridge and Olfert 2011). To assess how much of the relative "success" for the four transition counties is simply due to proximity to urban areas, the first column reports DISTMSA, which is distance in miles from the population-weighted centroid of the county to the population-weighted centroid of the nearest metropolitan area.[37] While closer than the average U.S. or ARC county, the four relatively successful transition counties are actually farther away on average than for all three other mining-intensive county groups. In fact, the poorest-performing mining-intensive counties were the closest, averaging only 8 miles away on average. Thus, it is uncertain whether urban access generally plays a tangible role for why the four relatively successful transition counties fared better.

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

Table 9: 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
Top 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
Top Ten Middle 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
Top 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: 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.
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.

The second measure 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), Economic Research Service using "warm winter, winter sun, temperate summer, low summer humidity, topographic variation, and water area."[38] Partridge (2010) reviews the literature showing that U.S. migration is attracted by nice climate and pleasant landscape with (net) moves toward warm winters, mountains, lakes, and oceans. The results show that the four successful transition counties have about an average level of natural amenities (a value of 3.5), which is also the case for the other three mining-intensive categories, Appalachia, and the U.S. Thus, differences in the natural attractiveness of the four successful transition counties is not the reason for their relative success. Yet, it is possible that the four "success" cases better leveraged their natural amenities for tourism and amenity migration.

The third geographical measure is the 2013 USDA rural-urban codes (RUC).[39] The RUC is a 1 to 9 scale with 1 being the most urban to 9 being the most rural. The details are apparent in the Table, but they confirm previous discussion. The four relatively successful coal-mining transition counties are definitely more rural than other mining-intensive counties, as well as relative to the U.S. or ARC. Again, they support the notion that relative urbanization does not explain their relative success.

The fourth geographical measure is TOPO, which is a 1 (flat) to 21 (most mountainous) topography scale used to calculate the USDA AMENITY measure (see AMENITY's source for more details of its construction). As was noted earlier, mountains can be an attractive magnet for migrants and to promote relevant tourist activities. However, unlike the Western U.S. Mountains with their typical wide valleys between mountains, mountainous Appalachian terrain is associated with a lack of level land for buildings and for roads, which hinders economic development. While more mountainous than the ARC average and especially the U.S. average, the four successful transition counties have an average of topographical score of 17.8, which is not generally different than the average for the other mining-intensive groupings, suggesting that average topography is not a general factor behind their relative success.

The 5th through 7th measures in Table 10 are sociodemographic factors that may support of growth and social stability. The 5th is the 2014-2018 Gini coefficient, which is a 0 to 1 measure

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[38] 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.

[39] 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.

Table 10: 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
Top 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
Top Ten Middle 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
Top 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. See the text for more details of variable definitions. Notes: 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.

of household income inequality. Zero reflects perfect income equality and 1 is perfect inequality. Again, it is remarkable that on average, all of the categories including the ARC and U.S, have Gini Coefficients that are approximately equal, suggesting that differences in inequality and the resultant negative social effects are not a factor in the relative success of counties.

The 6th measure is the 2018 county unemployment rate as estimated by the U.S. Department of Labor's local unemployment rate program. In interpreting the averages, note that the 2018 U.S. unemployment rate equaled 3.9%, but averages across groupings are higher because less-populated counties tend to have above average unemployment rates. Thus, it's not surprising that rural U.S. counties, including those in the ARC, had higher unemployment rates. This applies across the four relatively successful transition counties and the three mining-intensive categories, with no clear trend.

The 7th reported measure is the percent of the population that is white. Though it is unclear if the percent white (or alternatively percent minority) affects long-term success or failure, we report it as an important socioeconomic measure. The results suggest that rural ARC counties are heavily white, with no clear differences across the mining-intensive categories, again suggesting that this measure does not appear to explain differential long-term economic effects among our mining counties.

5.1.6 Social capital and local economic growth.

The next set of indicators is an assessment of social capital and local economic success in ARC coal country. Social capital is often defined as norms of trust, reciprocity and networks of relationships existing within local communities (Putman 2000). Social capital is important because it 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 of a need to draw up complex contracts or to monitor the behavior of other parties of the transaction. 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 downturn (Aldrich and Meyer 2015). In terms of economic development, social capital increases the cooperation necessary to support (and promote) new local investment and that there will be institutional support for winners compensating the losers (Reese and Rosenfeld 2002; Woolcock 1998).

Yet social capital may have unintended or counterproductive consequences (Putman 2000; Woolcock 1998). For example, high social capital may bind local residents together in close-knit communities yet these residents may lack "bridging" social capital that connects their communities to outsiders or others with innovative ideas that may change the local structure. A simple case is when residents in a small town are skeptical of outsiders and do not work to integrate them into their community. For example, the Great Plains region has high levels of social capital as measured by standard proxies, but it has experienced persistent out-migration over the last century. On the other hand, Las Vegas has limited social capital even if historically it is one of the fastest growing cities in the developed world.

Social capital cannot be directly measured. Instead there are proxies that are generally used to assess its magnitude. For example, researchers often use proxies such as the proportion of the population that engages in various local associations, vote, and voluntarily respond to the Census. The common theme is that people are engaging in behavior that in itself may have little benefit for them individually, but when acting collectively for their community, it can advance their community's interests—i.e., it serves a public good (Rupasingha et al. 2006).

The social capital measures are drawn from an updated version of Rupasingha et al. (2006).[40] The specific social capital proxies in Table 11 are: **sk2014** as 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** is voter turnout in the 2012 general election; **respn2010** is the 2010 Census household response rate; and **nccs2014** is the number of non-profit organizations including those with an international approach. While social capital may change over time, it is generally thought to be quite persistent at the local level. Generally, if social capital is a net positive influence for local economic development, then we expect these factors would facilitate the transition away from coal mining.

The first measure sk2014 is standardized such that it has a mean of zero and standard deviation of 1. Negative numbers reflect increasingly below average levels social capital and positive numbers increasingly reflect above average social capital. What stands out in Table 11 is that overall social capital is below average throughout the ARC region—i.e., for both mining- and non-mining-intensive counties. The four relatively successful transition counties are no different with below average social capital levels. Thus, their relative success does not appear to relate to possessing more overall social capital.

The remaining measures are sub-components of overall social capital. For the first measure, civic associations per 1,000 residents, the four successful transition counties have fewer per-capita associations than the other mining-intensive categories and the U.S. average. The patterns for voting participation, responding to the Census, and nonprofit associations all suggest that the successful transition counties have below average values. In sum, at least using traditional proxies of social capital, there does not appear to be any link with the relative success of ARC mining counties.

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

Table 11: Successful and Selected Counties' Social Capital Measures

County	State	SK2014	ASSN2014	PVOTE2012	RESPN2010	NCCS2014
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
Top 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
Top Ten Middle 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
Top 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
Sdt 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

Sources: **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. More details of these variables construction and source can be found in Rupasingha et al. (2006) and in the text.

Notes: 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.

While few quantitative studies have assessed local government capacity and its association with economic well-being across U.S. communities, a positive relationship could be posited. County governments with greater institutional capacity tend to be more active in social and business policy formulation and to provide more public services (Lobao et al. 2014). Fiscal resource autonomy, as measured by less reliance on external revenue is expected to make local governments more accountable to civil society and motivated to improve services (Pöschl and Weingast 2015). Localities that are able to raise greater revenues overall tend face lower barriers to improving conditions (Johnson et al. 1995). Local government spending and fiscal pressures are often treated as indicators of capacity (Sharp and Moody 1991). General public spending can create economic multiplier effects, reduce economic instability, improve infrastructure, and produce goods and services for local populations (Allard 2017). Fiscal pressures such as seen in a gap between revenues expenditures can deter governmental activities needed to create growth and local well-being (Johnson et al. 2015).

In keeping with the previous literature on governmental capacity, in Table 12 we display four indicators of county government fiscal autonomy (ratio of county own-source revenue to state/federal revenue), county own-source revenue per capita, county spending per capita, and the ratio of revenue to expenditures, an indicator of fiscal pressure. On average the 4 successful coal transition counties raise about half of their revenue locally, similar to the top 10 best performing mining intensive counties; and they (with the exception of Athens county) tend to experience slightly less fiscal pressure as indicated by a higher ratio of revenues to expenditures compared to other counties. (U.S. counties have to balance their budgets annually so a close association between revenues and expenditures is to be expected). Overall, however, along the indicators of institutional capacity, the 4 successful coal transition counties appear quite similar to the other counties in this study.

5.1.7 Health outcomes and local development.

Our final measures shown in Table 13 reflect local 1980 and 2014 health mortality rates. While these factors are not necessarily directly related to economic growth, indirectly communities with more social capital and fiscal capacity would be prone to have better health outcomes. Likewise, greater local economic opportunities may further reduce deaths that are often labeled “deaths of despair” such as drug overdoses and suicides. Thus, mortality rate data help proxy for the effectiveness to local social capital and government capacity to intervene in people’s lives.

Table 13 shows overall life expectancy for the four relatively-successful transition coal mining counties to be approximately equal to the average for the nation and above the average ARC nonmetropolitan county. In 2014, average life expectancy at birth equaled 77.3 for the four successful counties, 77.8 for the US, and 76.0 for the average ARC nonmetro county. The four successful transition counties exceeded the weakest performing mining-intensive and median-performing mining intensive counties by 1 and 4 years respectively, though they trailed the relatively best-performing mining-intensive counties by 0.6 years. This was the general trend that the four-transition counties greatly exceeded the median-performing mining-intensive counties, moderately exceeded the weakest-performing mining intensive counties and slightly trailed the best-performing mining intensive counties in the other more specific mortality outcomes.

Likewise, with one key exception, the average for the four relatively successful coal mining transition counties exceeded the performance of the U.S. average for the other mortality indicators—e.g., for suicides, alcohol poisoning, and violent acts.

The one exception was 2014 drug overdoses, which were driven by the opioid epidemic. The four-successful coal-mining transition counties had a drug overdose rate almost 40% above the U.S. average. Yet, the one county that was most alarming was Laurel County, KY, with a drug overdose rate of just over twice the U.S. average. Nobel County, OH had a 2014 drug overdose rate one-third below the U.S. average and a 2014 life expectancy that was 3 years above the U.S. average, with above average performances in the other indicators. Nonetheless, while this is only one outcome of social capital and government capacity, the relatively successful coal mining transition counties performed quite well in terms of limiting deaths, especially deaths of despair, given that they are remote rural counties.

Table 12: 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
Top 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
Top Ten Middle 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
Top 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
Sdt 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

Sources: 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 ($); FiscalStress: Revenue/Expenditures ($). The source is U.S. Census Bureau, 2012 Census of Local Governments.

Notes: 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.

Table 13: 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
Top 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
Top Ten Middle 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
Top 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

Sources: 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. The source of these variables is Institute for Health Metrics and Evaluation (IHME) as provided by Global Health Data Exchange, available at: http://ghdx.healthdata.org/record/ihme-data/united-states-mortality-rates-county-1980-2014.
Notes: 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.

6. FACTORS RELATED TO RELATIVE SUCCESS OF TRANSITION COUNTIES: CASE-STUDY ANALYSIS.

Here we present the results from our case-study analysis of the four transition counties in Appalachia and one outside the region that were more successful in generating growth. We provide descriptions of the types of opportunities and resources available within each community that likely account for their "success" in transitioning away from coal mining employment. We focus particularly on the role of distance/infrastructure, local industry and the non-mining economy, institutions/social capital networks, and population.

6.1 Case-Study Communities.

Information about the counties was located through several channels. First, for each case, we contacted at least five key individuals who potentially could serve as key informants about the county. We selected the contacts through: a search of county government websites; federal-state-county funded Extension Service offices (Extension agents provide development assistance to counties); and library and media outlets. We also asked the 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.

Given the current COVID-19 pandemic, locating and contacting individuals was challenging; one county Sequatchie proved particularly difficult as their website is limited and not updated. Informants were asked a series of questions about the factors affecting their county that could help explain the transition (e.g. distance/infrastructure issues, economy, population, institutions/government and social capital networks such as collaboration within the county and with outside entities). Second, we obtained information from a search of electronic resources including reports available from the Appalachian Regional Commission, newspapers and other media outlets, and other sources. Finally, we drill down into data from the U.S. Census, the ACS, and other secondary sources denoting these counties' socioeconomic well-being and other conditions over the past half century up until today (1970-2018). Beyond secondary sources, the information available about each county is uneven.

6.1.1 Athens County, Ohio.

The first community found to have successfully transitioned away from coal mining Athens County, Ohio. As noted, Athens County began its transition sometime between 1970 and 1980 as its population began to grow. Athens County's population was 54,889 persons in 1970 and it grew to 65,936 in 2018. The mean family income in 1970 was $56,889 (constant $2018) compared to $76,771 in 2018. Meanwhile the family poverty rate for Athens County in 1970 was 13.1 percent relative to 17.4 percent in 2018. As of 2017, the major industries of employment in Athens County were educational services (28 percent of employed residents), health care and social assistance (12.9 percent), and retail trade (11.4 percent) (Data USA 2020).

Athens County is home to Ohio University (a public, four-year college), Hocking College (a public, two-year college), and an Ohio Technical Center. 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 the 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 the decline in coal employment (Jolley 2020).

Thus, the story of Athens County's success appears to be heavily tied to the presence of a public university within the county. This is seen in Ohio University's rising enrollment, which more than doubled from about 8,000 students in 1960 to over 19,000 by 1970.

Location and natural amenities have also played a role in Athens' success. Athens has had easy access to its nearest major metropolitan area, Columbus, with U.S Route 33 constructed in 1938 running through it. Between Athens County seat (also named Athens) and the Columbus I 270 beltway, US 33 is mostly four lanes, much of it being limited access. The county is also been home to some recreation and tourism. Wayne National Forest, for example, is located in parts of Athens County.

In regard to institutional capacity and collaboration, according to Dr. Jolley, the nexus of the university, the ARC's regional economic development district (Buckeye Hills Regional Council) and small businesses and nonprofits within Athens county led to the necessary administrative capacity to pursue economic development strategies that have led to the county's continued economic diversification from coal. Mike Jacoby, the President of the Appalachian Partnership for Economic Growth, emphasized how these partnerships have benefited Athens County: "There have also been some companies formed, that grew out of the university: Global Cooling, Quidel (formerly Diagnostics Hybrids), and RXQ Compounding that 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 funding from the ARC and developed projects that the ARC considers innovative, such as those that develop philanthropic support and programs for youth including those that make use of local campus space (ARC 1999). Recent Power Grant funding from the ARC shows the county having received 7 grants out of the 23 received by Ohio counties (ARC 2020).

In regard to general social capital, Dr. Jolley noted the strong base in the county/city of Athens because of Ohio University. Due to the university's presence, he argued that the community shows a greater willingness to invest in arts, community events, and local cultures. Additionally, there is greater support 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 concern and focus on promoting environmentally sustainable practices that appreciate the negative impacts of coal mining on the environment and try to remedy those. For example, in partnership with Ohio University, Athens County received a grant from the EPA to work on water stream restoration to clean up streams in the county that had previously been degraded from coal waste.

6.1.2 Noble County, Ohio.

The second community found to have successfully transitioned away from coal mining is Noble County, Ohio, which began its transition sometime between 1990 and 2000. Nobel County's population was 10,428 in 1970 and increased to 14,443 as of 2018. The 1970 mean family income was $51,231, while it was $73,906 in 2018 (constant $2018). Finally, the family poverty rate for Nobel County in 1970 was 19.9 percent compared to 9.0 percent in 2018. As of 2017, its major industries of employment were health care and social assistance (16.9 percent), manufacturing (14.1 percent), and retail trade (12.8 percent) (Data USA 2020).

In assessing the factors important in transition, we located and 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 the following:

> "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.[41] 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).

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

Some additional opportunities for economic diversification also existed at the time of transition. The current development director of County Extension, Gwynn Stewart mentioned that during the period in which Noble County began transitioning away from coal employment, the Mahle Engine Plant was still operational, providing some good local jobs. However, Nobel County does not house any higher education or technical training institutions.

In terms of economic development opportunities today, Director Lloyd noted that Noble County, along with other counties in the region, have sometimes benefited from manufacturing plants since the decline of coal, but have seen many of factories close and move abroad, where production and labor costs are lower. B&N Coal is still has a small operation in Noble County today – so the community has not entirely left coal.

Geography has made some difference. Interstate-77 passes through the county. This further allows residents to commute elsewhere. Wayne National Forest is also located in parts of Nobel County. But the ability to recruit and expand industries within the county is limited by infrastructure. 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 service and broadband are still limited within the county, in which its mountainous terrain hinders their development.

Their record on networks and collaboration appears mixed. The Noble County Chamber of Commerce website indicates that its development efforts began formally with area businesses and professionals joining in 1971 and that collective efforts have been ongoing. As noted, County groups worked together and with the State Legislature to bring a state prison to the County. However, former Community Development Director Lloyd spoke to his own experience as working as a community development agent for Noble County. He stated there were many challenges to working in Noble County. First was the lack of non-governmental organizations and agencies that promote economic development. For example, he stated regional partners like United Way were not present in the county, and basic social services such as a homeless shelter or emergency medical services are nonexistent or limited. Second, his own experiences of trying to promote economic development included starting a small business development loan program, however, the program was underutilized and abandoned because there were too few individuals or organizations applied for loans.

Noble has collaborated with other counties to obtain funding for “innovative” grants projects from the ARC (ARC 1999). It also received two ARC POWER grants by 2020.

In short, it seems that Noble County benefitted from community efforts to secure a state prison and that while its population has grown as mining declined, it retains similar limitations including its small size and limited infrastructure as in it had in the past.

6.1.3 Laurel County, Kentucky.

The third community found to have successfully transitioned away from coal mining is Laurel County, Kentucky. Its transition occurred from the late 1980s-1990s. Laurel County’s population was 27,386 in 1970 but increased to 60,180 as of 2018. The 1970 mean family income was

$40,193, while it was $60,981 in 2018 (constant $2018). Finally, the family poverty rate for Laurel County in 1970 was 34.4 percent compared to 19.1 percent in 2018. As of 2017, the major industries of employment were retail trade (15.4 percent), manufacturing (13.9 percent), and healthcare and social assistance (12.9 percent) (Data USA 2020).

In the course of our case-study work, we contacted the City of London's Tourism Office (the county seat and major population center of Laurel County). When asked about what has contributed to Laurel County's growth, they stated that the primary reason Laurel County/London became a regional hub was due to the building of two major roads. Interstate 75, running north/south opened in 1969, and HWY 80, running east/west, now known as Hal Rogers PKWY, formerly as Daniel Boone PKWY, opened in 1971. They further noted that other communities east of Laurel County didn't have the advantage of the new interstate, and most of the counties along that corridor have seen progressive growth. There is also a regional airport established in the early 1970's. While London-Corbin Airport has no scheduled airline passenger flights, it is among the five busiest airports in Kentucky.

A respondent from the Laurel County Historical Society noted that money was spent to pipe water from Laurel Lake to London, which meant the city had the necessary water for factories. In 1960, Congress authorized construction of a dam on the Laurel River. The high dam, the Laurel River Dam, was built by the U.S. Army Corps of Engineers between 1964 and 1974 (hydropower production began in 1977) and provides low-cost hydroelectric power, safe supply of drinking water, and recreational opportunities (Laurel County 2020).

Additional roles of location are seen in tourism. Laurel County is where Harland Sanders once lived and it is home to the original Kentucky Fried Chicken. The County takes pride in its "annual world chicken festival" which is an apparent tourist draw. Daniel Boone National Forest spans parts of Laurel County, offering tourist amenities.

With its location and infrastructure, Laurel has tended to have a relatively diverse economy. Many durable and nondurable manufacturing plants are present in London, KY, such as Aisin – a Japanese corporation that produces components and systems for automobiles, Bimbo Bakeries USA, Flowers Foods, and others. In 2015, about 55% of the county's workforce were commuters from other counties and the county hosts 7 industrial parks.

The role of networks and collaboration in contributing to Laurel's turnaround is not clear. There is evidence of however 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." Today, 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, the story of Laurel County's resilience appears to be based on its location and infrastructural capacity. Also, the apparent long-running government collaboration within the County has leveraged greater economic development opportunities. The presence of an interstate highway likely facilitated greater industrial development by reducing transportation costs and increasing access for nearby commuters into Laurel County.

6.1.4 Sequatchie County, Tennessee.

The fourth, and final Appalachian case-study, found to have successfully transitioned away from coal mining is Sequatchie County, Tennessee. The transition occurred from the mid-1980s-1990s. Sequatchie County's population was 6,331 in 1970 compared to 14,730 in 2018. The 1970 mean family income was $42,550 compared to $64,711 in 2018 (constant $2018). Finally, the family poverty rate was 24.6 percent in 1970 relative to 14.3 percent in 2018. As of 2017, its major industries of employment were manufacturing (15.7 percent), retail trade (12.6 percent), and healthcare and social assistance (11.6 percent) (Data USA 2020).

Location also played a key role in Sequatchie County. It has been part of the Chattanooga, TN Metropolitan Statistical Area since 1973 and this proximity undoubtedly contributed to its growth. Two major highways, U.S. Route 127 and Tennessee State Route 111, intersect in Dunlap, the county seat. In the course of our case-study work, we contacted the Southeast Tennessee Development District Director Beth Jones who has 38 year of experience working in the county. Her summary of Sequatchie County's transition from coal employment is 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 ADHS Corridor, U.S. Highway 111, otherwise 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 2 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 is part of the Cumberland Plateau, sitting more than 1000 feet above the Tennessee River Valley, providing recreational and scenic opportunities (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 resilience appears to be facilitated by being in the Chattanooga metropolitan area. The proximity of the county to Chattanooga allows for Sequatchie's residents to access a more diverse employment base.

6.1.5 Ouray County, Colorado.

Our final case study is a non-Appalachian, Ouray County, Colorado. It successfully transitioned away 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 as coal mining, but being in the Western United States gives it a different set of structural and cultural characteristics than Appalachia. Also, as noted before, the topography of the Rocky Mountains typically has more developable land than in the Appalachian Mountains.

Ouray, County's transition away from mining occurred from 1970 to 1980. Ouray County's 1950 Population was 2,103, falling to 1,537 in 1970. Yet, by 2018, its population more than tripled to 4,722. The 1970 mean family income was $49,029 compared to $87,907 in 2018 (constant $2018). Finally, the family poverty rate was 11.4 percent in 1970 relative to 7.0 percent in 2018. As of 2017, its major industries of employment 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. In fact, Ouray County is referred to as "the Switzerland of America," due to its rugged mountain topography which host 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 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).

Another aspect of Ouray's tourism success was the early development of highways through surrounding mountains. For example, the "Million Dollar Highway" is the name given to the stretch of U.S. Highway 550 from Ouray to Silverton. The highway began as the Otto Mears toll road that was 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 resilience appears to be based on its location and natural amenities that make it a desirable tourist destination. The presence of a federal highway likely eased its transition to a tourism-based economy. To be sure, like the four ARC case studies, notice that having a large population is unnecessary for a community to be resilient to the end of its mining base.

6.2 Economic Benefits and Impacts of the Appalachian Development Highway System.

The Appalachian Development Highway System (ADHS) is the first highway system authorized by Congress for the express purpose of stimulating ARC economic development. In total, 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% completed, with another 5% open to traffic, but planned enhancements not completed. Only 340 miles are unconstructed, though a final completion date is uncertain (ARC 2020). The purpose of the ADHS is to generate economic development in previously isolated areas and, by integrating the Appalachian region to the national transportation system, provide access to regional, national, and global markets.

Figure 10 shows the ADHS system as framed in the original 1966 ARC plan, while Figure 11 shoes the system as it exists and is envisioned today (showing that the planned ADHS slightly expanded over time). As of 2016, over $34 billion in federal expenditures have gone to the ARC, 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 and largely exist in the form of travel time and reliability. In their analyses of the 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 due to greater reliability" (Economic Development Research Group, Inc. 2017, p. 5).

Besides providing travel cost savings, the ADHS has had substantial impacts on the accessibility of Appalachian communities to labor markets. In particular, the success of the ADHS appears to promote labor force accessibility in areas that are remote from major population centers, as well as in economically distressed counties (Economic Development Research Group, Inc. 2017). The investments made in the ADHS have enabled the ARC region to attract business investment and economic growth – these benefits are annually estimated to be over $24 billion of added business sales and $11 billion per year of added gross regional product ($2015) compared to estimates of what would be the case without the ADHS (Economic Development Research Group, Inc. 2017).

Figure 10. Map of Planned Appalachian Development Highway System in 1966

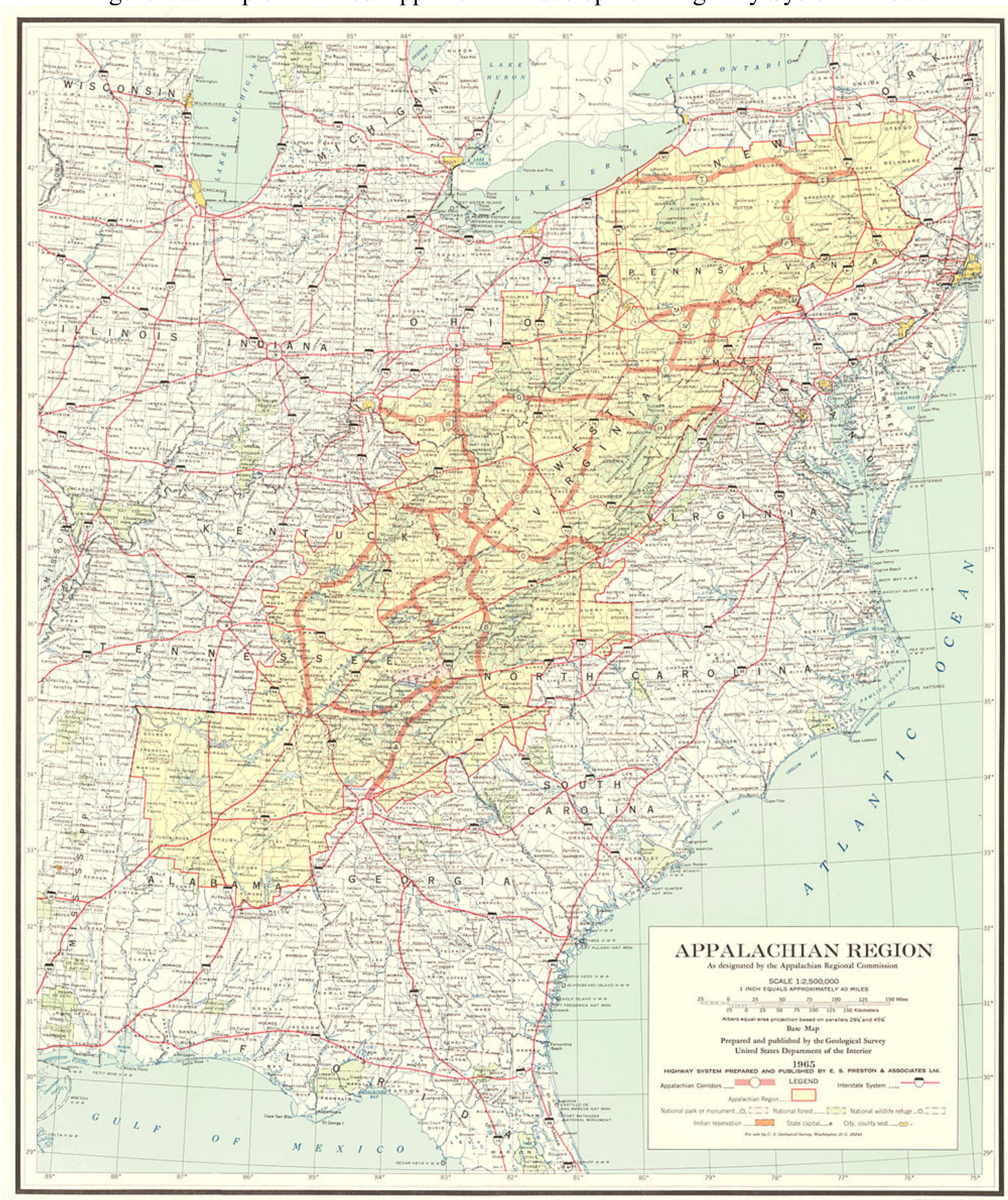
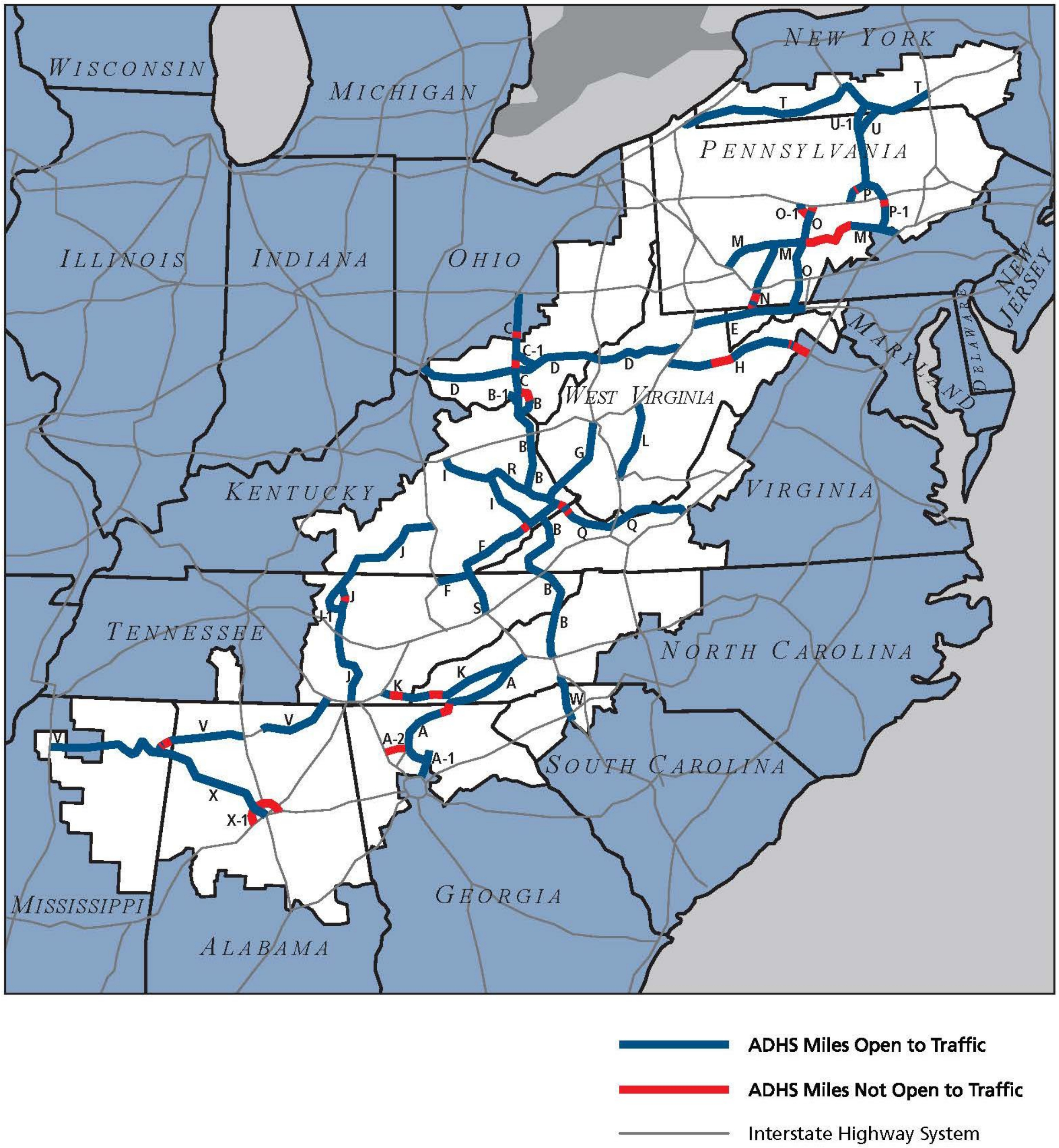
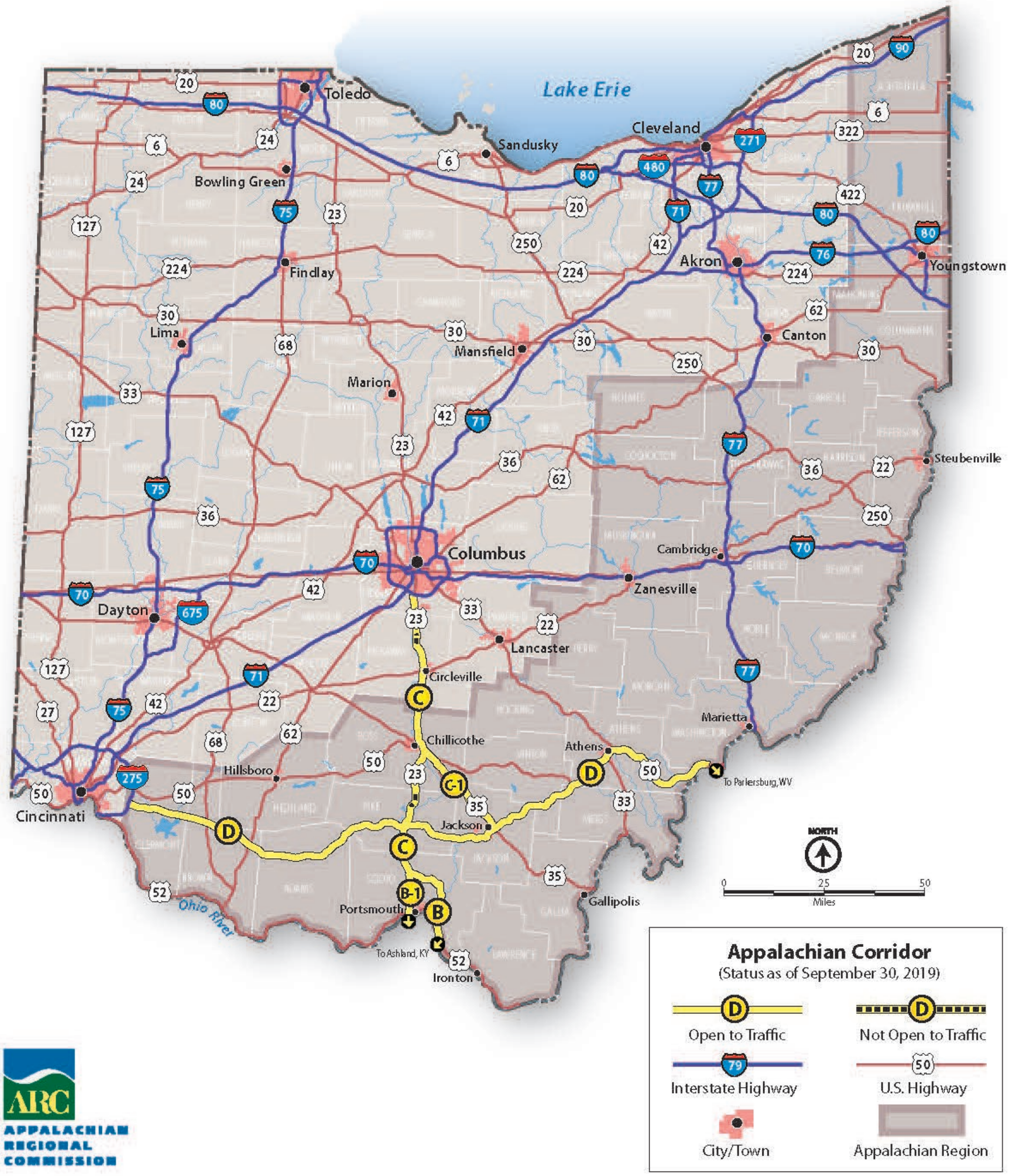


Figure 11. Map of Planned Appalachian Development Highway System in 2017



We now turn to the specific benefits of the ADHS corridors in 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. While the ADHS does not intersect with Noble County, OH – it benefits from being crossed by U.S. Interstate 77. In Figure 12, Noble County can be seen directly north of Marietta in southeast Ohio, approximately where the Interstate 77 symbol is located.

Figure 12: Appalachian Development Highway System Corridors in Ohio



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6.2.1 Athens County, Ohio.

Athens County, Ohio has benefited from the ADHS's funding of corridor D, which is U.S. Highway 50. Corridor D was part of the initial ADHS highways funded in 1965, and is the major east-west route in southern Ohio (see Figure 12). While Athens County is 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. According 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).

6.2.2 Laurel County, Kentucky.

Laurel County, KY has also benefited from the ADHS in the presence of Corridor J intersecting the county. Figure 13 shows that Corridor J's northern terminus is Interstate 75 near London, KY, the county seat of Laurel County. Laurel County's additional access to Interstate 75 is also noteworthy because that interstate is a critical transport route for U.S. manufacturing supply chains, especially for the auto industry.

The construction of Corridor J began in 1970 and completed in 1984. The Kentucky counties that Corridor J runs through include: Laurel, Pulaski, Wayne, Clinton, and Cumberland. The economic impacts are estimated to be: 3,785 additional jobs and an additional $140 million in income (Econ Works 2020). According to a 1998 study on the economic impacts of the ADHS, "the reconstructed route shaved 5.7 miles off the route resulting in a reduction of 29.4 million vehicle-miles-traveled annually (5% drop), and cut the drive time by over 29%, resulting in annual time savings of 4.4 million vehicle-hours-traveled" (Econ Works 2020; Wilber Smith Associates 1998).

6.2.3 Sequatchie County, Tennessee.

Sequatchie County, Tennessee is also on ADHS Corridor J near its terminus in Chattanooga. The section of Corridor J, between Dunlap, Sequatchie's county seat, and US 27 was built between 1988 and 1994 (Tennessee State Route 111, 2020). This section provides an additional commuting route into Chattanooga by connecting Sequatchie to US Highway 27 –enabling the ability of county residents to be able to directly commute to employment in the core of the Chattanooga metropolitan area (see Figure 14). The U.S. Census Bureau estimates that the 2019 Chattanooga city population was 183,000, whereas the metropolitan area was 563,000.

Figure 13: Appalachian Development Highway System in Kentucky

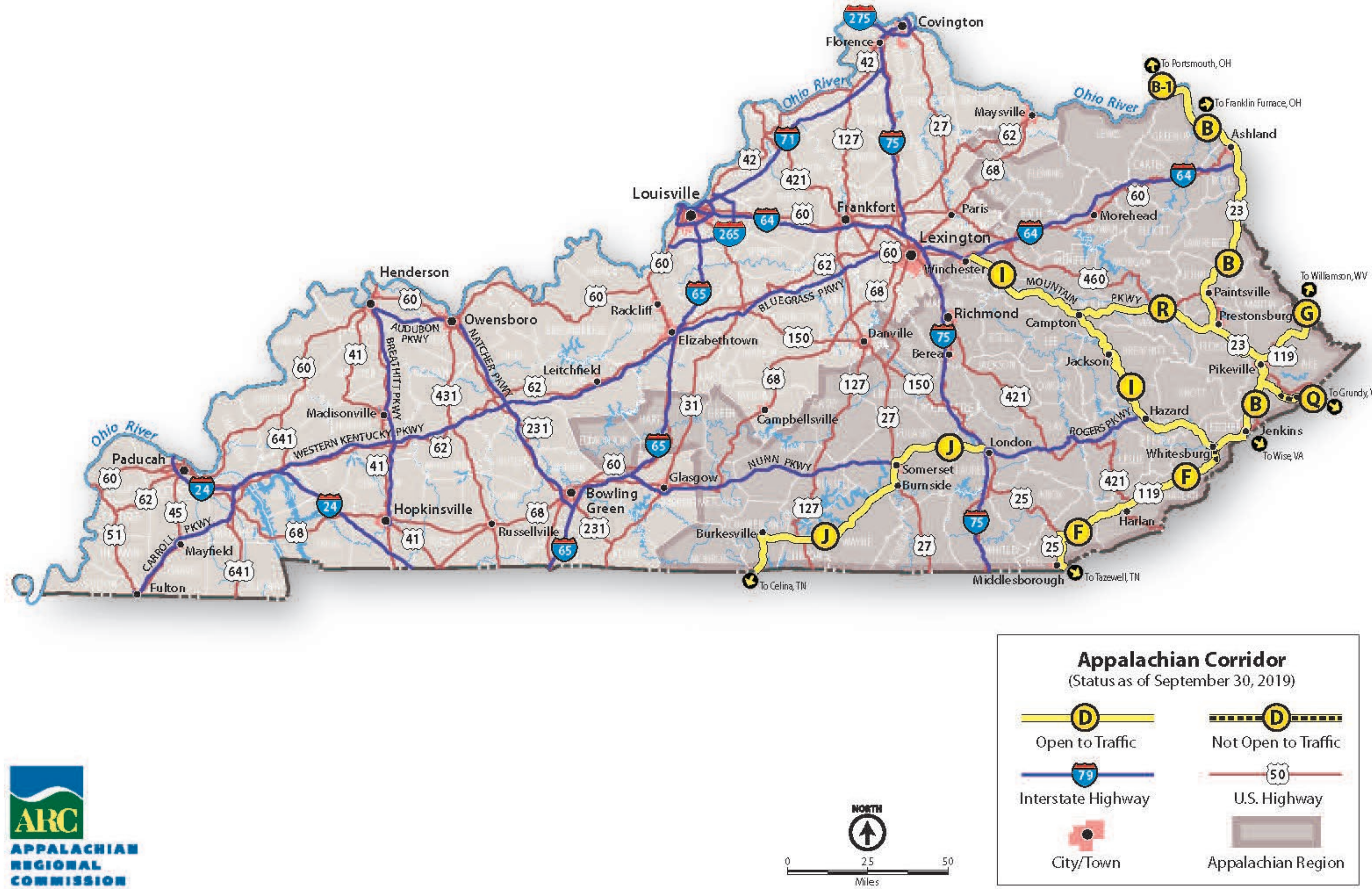

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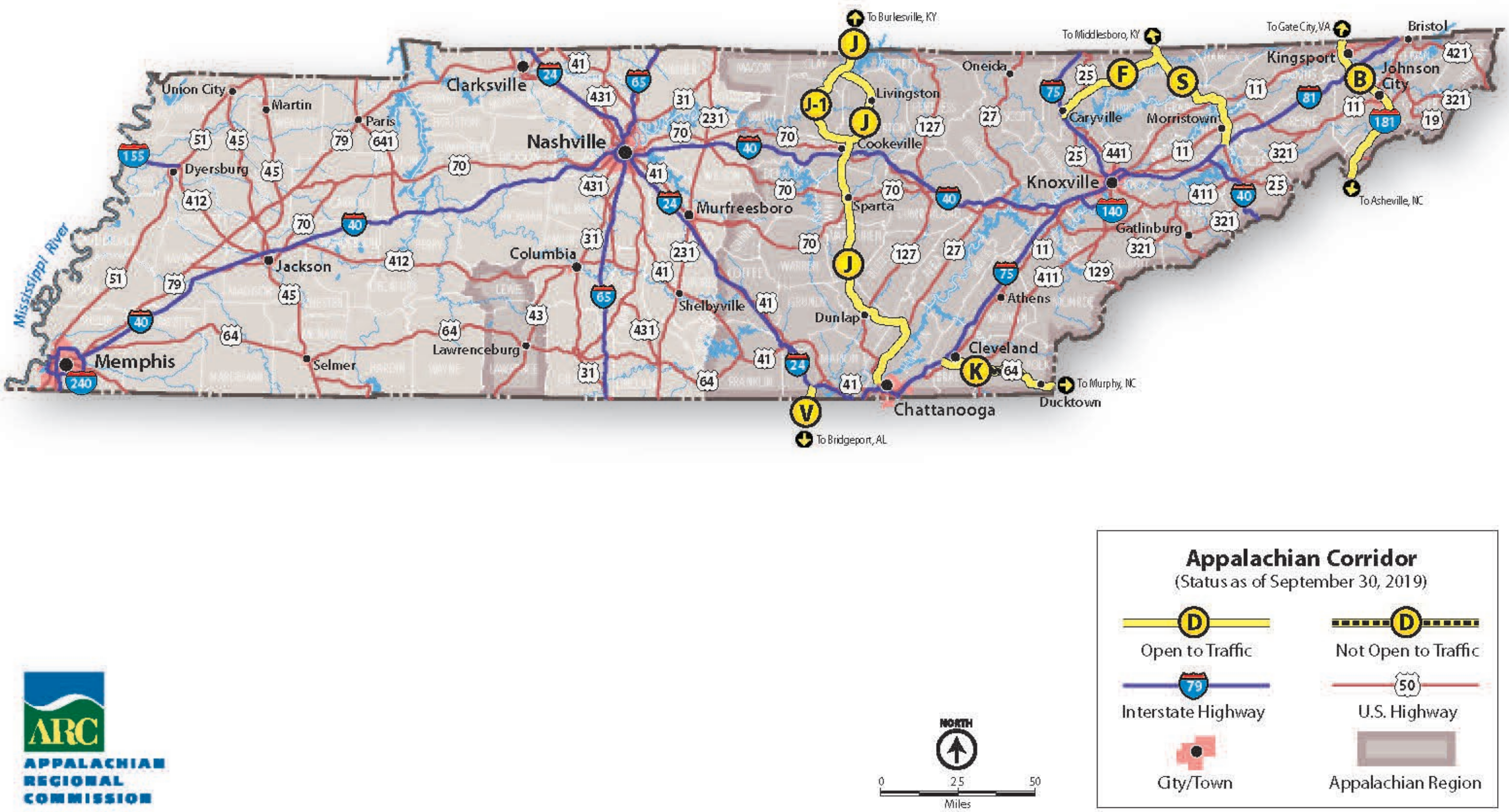
Figure 14: Appalachian Development Highway System in Tennessee



6.3 Summary: Lessons Learned from the Case-Studies.

Drawing together the findings from our five case examples yields the following conclusions.

- Each county is characterized by a unique configuration of factors that have influenced their growth with few clear, cross-cutting determinants. As a whole, the factors identified in the case-studies are not dissimilar from those we found in the general literature review and targeted review but it is important to stress that there is no single thread of determinants that makes the four relative success counties stand out compared to their counterpart Appalachian counties.

- Structural and institutional factors denoted earlier (distance/rural location, the non-mining economy, local governmental capacity, and social capital networks) play some role across the cases. However, the degree of importance of each of these factors varies and collectively they are not clear determinants of better future performance in each county case. For example, government investments appeared to have helped in all cases, but the ARC region is filled with distressed regions that also received significant government investments beginning with the Tennessee Valley Authority (TVA) in the 1930s.

- Highway infrastructure in place around the time of transition has been important to subsequent county performance, suggesting that it is a necessary component of subsequent success. All four relatively successful counties contain major highways and two have federal interstates. Ouray County, Colorado likewise contains a federal highway. Two counties became bedroom communities (Sequatchie for the city of Chattanooga and Noble for neighboring counties) and two (Athens and Laurel) grew into regional hubs for surrounding areas. Yet, the investments in the federal interstate highway system and in the ADHS has strongly affected most of the ARC region, whether economically successful or not, meaning that highways in themselves are insufficient for subsequent success of coal mining communities.

- All five counties (including the success story from Colorado) possess natural amenities (such as national forests, rivers, and scenery) that create opportunities for recreation and tourism and increase the desirability of the county as a place to reside. However, again, almost all of the ARC region possesses natural amenities.

- Public sector investments appear to have spawned the growth in the case of three counties. Athens contains a research university that serves southern Ohio as a source of human capital. Noble County has relied on prison development, the county becoming the site of a state prison in 1996. Likewise, Laurel County was the site of a major dam that led to enhanced water supply, low-cost hydroelectricity, and recreational opportunities. Yet, beginning with the TVA, followed by the ARC, and more idiosyncratic efforts of the region's federal representatives, almost all of the region has received significant federal investments (e.g., Late West Virginia Senator Robert Byrd was legendary for this), suggesting that government investment in itself is not sufficient for subsequent growth.

- Tourism, beyond natural amenities plays a broader in role two Appalachian counties (Athens and Sequatchie) which have worked to become regional destinations for festivals and/or the arts. Tourism is highly important in the case of Ouray, the Colorado County.

- Only one county (Laurel) has a strong and diverse industrial base composed of durable and non-durable manufacturing firms. Yet, as noted in the previous Chapter, manufacturing appears to have been an impetus in the four success cases, and at least early in the development process, so did agriculture. Likewise, early in the transitioning process, greater entrepreneurship appears to also have played a role.

- Local governmental capacity with regard to administrative leadership to promote community development varies across the counties. Athens has a history of active engagement in economic development, local arts and cultural programs, social service provision and public-private and cross-county collaborations. The county is particularly active in grant-seeking from government and non-profit sources. Sequatchie and Laurel local governments have long been active in economic development focused on external business attraction and investment. Noble County appears least active with informants noting periodic engagement in economic development and limited social services.

- Social capital networks in terms of bonding (internal) and bridging (external) capital appear high only in Athens. University linkages, public-private partnerships, and a willingness to invest internally in the community along with external linkages to state and other local governments were noted. Indeed, as pointed out in the previous chapter, there does not appear to be a systematic advantage in social capital for the four relative success counties, though at least in terms of health outcome, they appear to over-perform.

- Among the four relatively successful coal-transition ARC counties, Athens presents the only evidence of what might be considered a cultural shift facilitating transition. A key informant noted that partly owing to Ohio University and the diverse population from which it draws, relative to other ARC communities, there is greater appreciation of the arts and local culture, the promotion of more environmentally sustainable practices, and efforts to remedy negative environmental impacts of coal.

- In terms of policy, all four relatively successful transition counties have benefited from the ARC. All are a part of multi-county local economic development areas established by the ARC that provide access to funding opportunities. Athens has been particularly active in securing POWER grants awards, a congressionally funded initiative administered by the ARC which targets federal resources to help communities and regions affected by job losses in the coal industry. All four counties have benefitted from the ARC's the ADHS.

7. LESSONS LEARNED AND POLICY GUIDANCE.

Here we synthesize the lessons learned from the case studies, the quantitative analyses, and literature review to produce some policy guidance behind promoting "successful" transitions from coal mining and/or to accelerate this transition in most just way possible.

The above discussion of the case studies point to: (1) the idiosyncratic nature of each case makes it difficult to observe general trends, and (2) the small number of successful cases means that caution should be exercised when trying to extrapolate from them—i.e., the external validity may be limited. Yet, there are some general patterns that appear to promote ultimate success.

The context is that Appalachian coal country has been under pressure since the late 1940s, with declining coal employment and net-outmigration of residents. The region's 2018 coal employment was barely 30,000 including just under 14,000 in West Virginia (EIA 2020). As described earlier, coal usage in U.S. electrical generation has been especially hit in the "Covid-19 Recession" with Appalachian coal production falling about 46% in the year ending the week of May 9.[42] Yet, despite the shrinking coal economic footprint, the political support for the coal-mining industry is one key reason behind political gridlock in climate change regulations.

Wide sweeping policy changes are needed to both ensure and assure coal-miners are left whole and that coal country is supported in general. Social justification underlying a far-reaching government relief/restructuring plan for coal country is based on how the entire nation historically benefited from the energy produced with coal, but coal-country itself had to pay almost all of the external (direct) environmental costs along with economic costs of being tied to a volatile boom-bust industry associated with a range of negative socioeconomic consequences—e.g., the natural resource curse. Individual miners paid with high risks of crippling injuries and afflictions like Black Lung Disease, in which incidence of Black Lung Disease has greatly increased since 2000 and the prevalence of the most severe forms of Black Lung Disease is at its highest on record dating back to the early 1970s (Centers for Disease Control 2018; Potera 2019). Thus, given these large-scale human and broader social costs that has faced coal mining regions, providing massive support can be justified in order to accelerate the transition to a cleaner more prosperous future. Given the relatively small number of people affected in developed countries such as the U.S., its costs are manageable. As noted earlier, coal mining is no longer an industry that employs significant numbers, it generally occurs in sparsely populated regions, and not all communities would be affected at once.

Place-based efforts to economically revive coal-country communities are likely viewed as highly insufficient by affected residents, and as far as the residents and miners are concerned, it effects would be indirect in that it is far from certain that they will *directly* benefit from such efforts. Coal regions like Appalachia or lagging regions in general have typically seen many place-based policies, in which the ARC or TVA are clear examples. Yet, coal regions still typically lag the nation, meaning residents may be skeptical that place-based programs will ensure their own individual success.

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[42] U.S. EIA, *Weekly Coal Production* (downloaded from: https://www.eia.gov/coal/production/weekly/. on May 19, 2020).

8. CONCLUSION.

This project assessed the factors that facilitate a more successful community adaption after coal transition. A key goal is to address questions about why some communities perform better and to inform best practices to promote a more "just transition" as market realities and policies to mitigate climate-change spur adaptation. The study considers Appalachia, a U.S. region significantly affected by coal sector decline.

Appalachia's development has historically lagged. For decades, it had some of the lowest per-capita income levels and highest poverty rates in the U.S. (Lobao et al. 2016). To address these issues, the ARC was established in 1965, covering parts of 13 states and includes 420 counties.

From the early 19th century, Appalachia was the primary U.S. coal producer, but its reign as the dominant coal region began to wane in the late 1960s as production shifted west. By 1998, Appalachia's share of U.S. coal production was 41% and it fell to 27% in 2018 (EIA 2019). Meanwhile, its national share of coal employment declined from 85% in 1954 to 57% in 2018. In sum, Appalachia's coal-country is quite vulnerable to the fortunes of coal mining.

Little is known about how Appalachian communities adapted as employment shifted away from coal in the post-WW II era. This research focuses on four related questions:

1. Which ARC communities made a relatively successful transition away from coal mining?
2. What were the resulting socioeconomic outcomes in these communities?
3. What factors mattered for ARC communities that recovered more successfully?
4. What are the lessons learned from this research? What key factors contribute to socioeconomic revitalization in transitioning away from coal?

Our research addressed these gaps through a quantitative analysis of the ARC's 420 counties, along with qualitative information on four "relatively successful" ARC coal mining communities that transitioned from coal. We also did an extensive a literature review that examined extractive industries and factors promoting positive community outcomes, especially in rural areas.

8.1 Identifying Factors Promoting Community Well-being: Literature Review Findings.

We evaluated past studies to identify factors that potentially support community revitalization in the wake of coal transition. Four sets of related factors are identified. First, geographic attributes such as urban-rural location, proximity to urban centers, and population. Second, local industrial structure, especially a relatively high wage structure. Third, sociodemographic factors such as education, age, race/ethnicity, and family structure. Fourth, local institutional factors such as local government capacity and social capital.

Regarding natural resource dependent communities, researchers point to the natural resource curse to explain why they typically fare poorly over the long-run. They note that extractive industries often lead to displacement of other industries, less diverse local economies, underinvestment in education and lower human capital. These issues along with the remote rural location of many extractive communities suggest a difficult path toward revitalization.

8.2 Appalachian Communities that Made a Relatively More Successful Transition.

8.2.1 Historical background.

Several key historic forces shape the current Appalachian coal mining situation. One is rapid labor-saving productivity growth in coal mining since 1919 has been the primary reason for declining coal employment. Between 1919-2017, short-tons of coal produced per coal miner rose over 21 fold—rising from 720 tons to 15,367. Between 1923 and 2019, U.S. coal mining employment fell 94%, or over 800,000 jobs. Beginning in the late 1960s, the second trend that adversely affected ARC coal mining was the shift of coal mining from Appalachia to the Northern Great Plains (NGP) due to vastly higher productivity in NGP strip mines and NGP coal having lower Sulphur dioxide content that was preferred due to air quality regulations.

The third was a realignment of coal mining from Northern Appalachia—Pennsylvania and Ohio—to Central Appalachia, primarily Kentucky and West Virginia. Between 1919 and 2017, Pennsylvania and Ohio lost 98% of their coal mining jobs, while Kentucky and West Virginia lost a "mere" 85%. Since 2006, coal has faced a growing threat due to rapidly falling costs of natural gas caused by new shale-drilling technologies. By 2017, coal employment even in the three most coal-intensive ARC states stood at 14,000 in WV, 6,500 in KY, and 5,400 in PA. Going forward to 2050, continued pressures due to environmental regulations, ongoing coal mining productivity growth, and increasing competitiveness of natural gas and alternative energies mean that coal employment will be minuscule.

8.2.2 Identifying successful coal transition counties.

To select counties that transitioned from coal, we followed a detailed protocol. To be considered a "relatively successful" coal-transition county, the following criteria had to apply:

1. The county had to be coal mining intensive in either 1950, 1980, 1990, and 2000.
2. The county had to have a *subsequent period* in which coal mining was an insignificant part of the local economy—i.e., the county transitioned away from coal mining.
3. For population growth, the county had to relatively "overachieve" using regression analysis for one of the following periods: 1950-2018, 1980-2018, 1990-2018, and 2000-2018.
4. The county's population growth had to exceed the ARC average in at least one decade.

The analysis identified 4 success counties out of 222 ARC counties that were classified as mining dependent during some period. With only 4 success cases out of 420 ARC counties, the findings suggest that it is very difficult to successfully transition away from coal, and for the ARC region, mining-intensive counties appear to have suffer from the *natural resource curse*.

Less than 15% of mining-intensive ARC counties (32 out of 222) grew faster than their corresponding 1950-2018 ARC average population growth. From this pool of 32 potential candidate counties that experienced some period of above-average growth, only four met the criteria for "successful coal transition counties":

1. Sequatchie County, in southeastern Tennessee (transition period mid-1980s-1990s)
2. Laurel County, in southeastern Kentucky (transition period late-1980s-1990s)
3. Athens County, in southeastern Ohio (transition period 1970-1980)
4. Noble County, in southeastern Ohio (transition period 1990-2000)

8.2.3 Other outcome measures for coal transition counties.

We gauge other outcome indicators (in addition to population growth) that are associated with better socioeconomic outcomes and how the four counties compare to other mining-intensive counties. The four "relatively successful" counties are compared to 10 highest-, 10 median-, and 10 poorest-performing Appalachian mining counties. (The 30 counties were selected from regression analysis that yielded data for 99 mining-intensive counties.)

- Overall, the four successful coal transition counties are doing better than most "over-performing" mining-intensive locations in population growth since 1990 and they are growing much faster than those in the middle or at the bottom.

- Yet median income and poverty rates in the four counties show less favorable outcomes as compared to highest-performing mining-intensive locations and are closer to the median-performing mining counties.

8.3 Factors Explaining Why the Four Appalachian Counties Fared Better than Others.

To examine why the four Appalachian counties were able to gain greater ground than others, we conducted a quantitative as well as qualitative analysis. Both analyses focused on the role of four key factors identified above that include geography, economic structure, sociodemographic characteristics, and institutional characteristics with the qualitative analysis allowing for additional elaboration.

The quantitative analysis compared the four relatively successful coal transition Appalachian counties to the 10 highest-, 10 median-, and 10 poorest-performing Appalachian mining counties using a range of variables measuring geography, economic structure, and sociodemographic and institutional factors. Based on this analysis, we found no clear patterns that indicate why the four cases relatively succeeded in their transition process. For example, proximity to urban centers, educational attainment, age structure, social capital and local governmental indicators were not markedly different when the four cases were compared to other counties. There were some exceptions, however, where the four cases displayed slight advantages which include higher initial shares of the self-employed, a higher percent of workers employed in manufacturing during the transition process, and somewhat better mortality rates.

In the qualitative analysis, we collected information from key informant interviews, electronic resources, and secondary sources to identify factors that explain why the four Appalachian coal transition counties had performed relatively better. As noted, we focus on the role of structural and institutional factors and other factors specific to each case. For comparison, we also included the characteristics of rural Ouray County, Colorado. The following are our findings.

- Each county is characterized by a unique configuration of factors that have influenced their growth with few clear, cross-cutting determinants.

- Structural and institutional factors denoted earlier (distance/rural location, non-mining economy, local governmental capacity, and social capital networks) play some role across the cases. However, the degree of importance of each of these factors varies and collectively they are not clear determinants of better future performance in each county.

- Highway infrastructure in place around the time of transition has been important to subsequent county performance. All four Appalachian counties contain major highways and two have federal interstates, which has spurred their growth. Two counties became bedroom communities (Sequatchie for the city of Chattanooga and Noble for neighboring counties) and two (Athens and Laurel) grew into regional hubs for surrounding areas. We caution that historically, many coal mining intensive ARC counties also had significant investments in roads and other public infrastructure—suggesting that public investments may be necessary but are not sufficient for ultimate success.

- All the counties possess natural amenities (such as national forests, rivers, and scenery) that create opportunities for recreation and tourism and increase the desirability of the county as a place to reside.

- Public-sector development promoted growth in three counties. Athens contains a major regional research university system. Noble County relied on a state prison development in 1996. Laurel County received significant highway investment and a dam was constructed that provides low-cost hydroelectricity and outdoor recreation opportunities.

- Tourism, beyond natural amenities, plays a broad role in two counties (Athens and Sequatchie), which have worked to become regional destinations for festivals and/or the arts. Tourism is highly important in the case of Ouray, the Colorado county.

- Only one county (Laurel) has a strong and diverse industrial base composed of durable and nondurable manufacturing.

- Local governmental capacity with regard to administrative leadership to promote community development varies across the counties. Athens has a history of active engagement in economic development, local arts and cultural programs, social service provision and public-private and cross-county collaborations. The county is particularly active in grant-seeking from government and nonprofit sources. Sequatchie and Laurel local governments have long been active in economic development focused on external business attraction and investment. Noble County seems the least active with informants noting only periodic engagement in economic development and few social services.

- Social capital networks in terms of bonding (internal) and bridging (external) capital appear high only in Athens County. Their university linkages, public-private partnerships, a willingness to invest internally, along with external linkages to higher-level governments were noted.

- Among the four Appalachian counties, Athens appears to be the only one that experienced a cultural shift facilitating transition. A key informant noted that partly owning to the university and the diverse population it draws, relative to other Appalachian communities, there is greater appreciation of the arts and local culture, the promotion of more environmentally sustainable practices, and trying to remedy negative environmental impacts of coal.

- In terms of policy, all four Appalachian counties have benefited from the ARC. All are a part of multi-county groups of neighboring counties established by the ARC which provide access to funding opportunities for group projects. Athens has been especially active in securing POWER grants, a congressionally-funded initiative administered by the ARC that targets communities affected by coal mining job losses. All four counties have benefitted from the ARC's Appalachian Development Highway System. However, as noted above, less-successful counties have also received such state and federal investments, making it difficult to assess what is *sufficient* for eventual economic success.

8.4 Summary: Lessons Learned and Policy Implication.

Based on the literature review of best-practice development and the qualitative and quantitative analysis, we believe there are several policy guidelines that can generally inform the fastest and most just transition from coal mining. The following summarizes those guidelines:

1. From the coal miners' perspective, they possess a property right over their job and it is the government that is taking **<u>their</u>** job. If governments want to reduce opposition to transitioning from coal, they need to consider a "buyout" of coal miners in order for miners to confidently believe they will be made whole—much akin to how large corporations buyout senior management. Miners' view of having a "property right" underlies their antagonism to using less-generous standard income support programs.

2. Generous training and education programs should also be provided to affected coal-mining workers.

3. Higher-level governments should consider back-filling lost tax revenues for coal-country local governments. After a sufficient time, such subsidies should cease.

4. Coal communities are highly disadvantaged economically due to many factors. For one, environmental damage caused by the legacy of mining and related manufacturing industries deters foot-loose high-skilled workers and entrepreneurs from locating in coal

country. Since “good” jobs will be much more difficult to create in coal country, many coal-country workers will likely need to relocate to good jobs. Migration assistance is then necessary to effectively support households who wish to relocate to more prosperous areas.

5. Sustainable economic development of local communities requires a clean environment, including a clean-up of legacy mining sites. Environmental cleanup is also a source of employment for many displaced coal mining workers.

6. The general best-practice local economic development strategy is well-known: (1) diversify the local economy; (2) leverage natural amenities for tourism and related businesses, attracting part-year residents, and attracting new residents who can “telecommute” from anywhere, and (3) promote small business and new-firm development (Partridge and Olfert 2011; Tsvetkova et al. 2019). The promotion of local entrepreneurship is critical.

7. In the near term, declining coal-country businesses need financial support to survive hard times. A policy of providing grants and bridge loans to struggling businesses would cushion the blow, allowing local businesses breathing room.

8. There are typically a myriad of government programs that support lagging coal regions. A capable higher-level agency helps facilitate economic transition by coordinating these efforts across differing economic development agencies, nonprofits (e.g., Chambers of Commerce), and numerous local governmental authorities. The ARC provides a good example because of its Local Development Agencies (LDAs). The LDAs are multiple-county economic development regions that coordinate regional economic development by bringing the relevant players together. LDAs serve as brokers that help initiate or support multi-actor projects by coordinating the parties and providing seed money to get projects off the ground. A robust higher-level development agency can also provide much needed governmental capacity for sparsely populated counties, which often lack basic skills for basic functions.

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APPENDIX 1: 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:

$$\begin{aligned}\Delta population_{t,t+j} &= \alpha_0 + \alpha_1 Mining\ Employment\ Share_t + \alpha_2 (Mining\ Employment\ Share_t)^2 \\ &+ \alpha_3 Population_t + Metropolitan_{1973} + NonAppalachian + Region\ ,\end{aligned}$$

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 Employment Share 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 1, Figure 11 provides a map of these ARC regions and Appendix 1, Figure 12 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.[43]

Before describing additional steps in identifying successful transition counties, we briefly discuss the empirical results. Appendix 1, 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.

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[43] A metropolitan area is defined by the U.S. government as a city (urban cluster) of at least 50,000 population along with its own-main county and any other county with at least 25% commuting linkages with the principle city(ies). In other words, the U.S. definition of a metropolitan area is a local labor-market area. We also tried using the 2013 metropolitan area definition, but in all cases, the 1973 definition fit the data better, which likely relates to more recent county additions to metropolitan areas that are often so distant from the principle city that they do not receive large agglomeration-economy benefits.

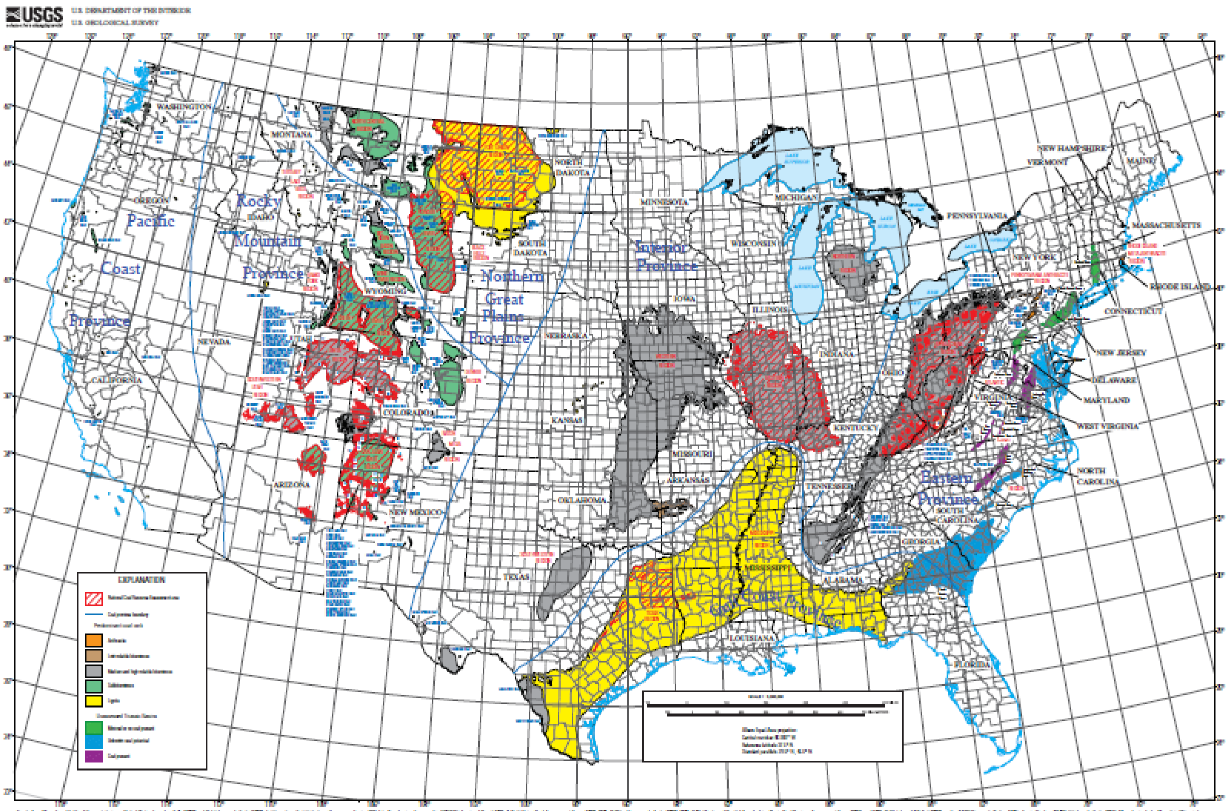
The regression results are generally expected and consistent across models. For example, the mining share coefficient is negative and statistically significant in all three cases, while the squared mining share coefficient is positive and statistically significant in two out of three cases. For the 1950-2018 model, taking the derivative of mining share and its square yields a positive marginal relationship on population growth with a share > 42%, and in the 2000-2018 model, the marginal association turns positive after the mining employment share surpasses 12% (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 1 Table 1: Regression Estimates for Selected Time Periods

	(1) Summary Stats	Regression results		
		(2) Population Growth 1950 to 2018	**(3) Population Growth 1980 to 2018**	**(4) Population Growth 2000 to 2018**
%Population Growth 1950 to 2018	94.46 (215.02)			
%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

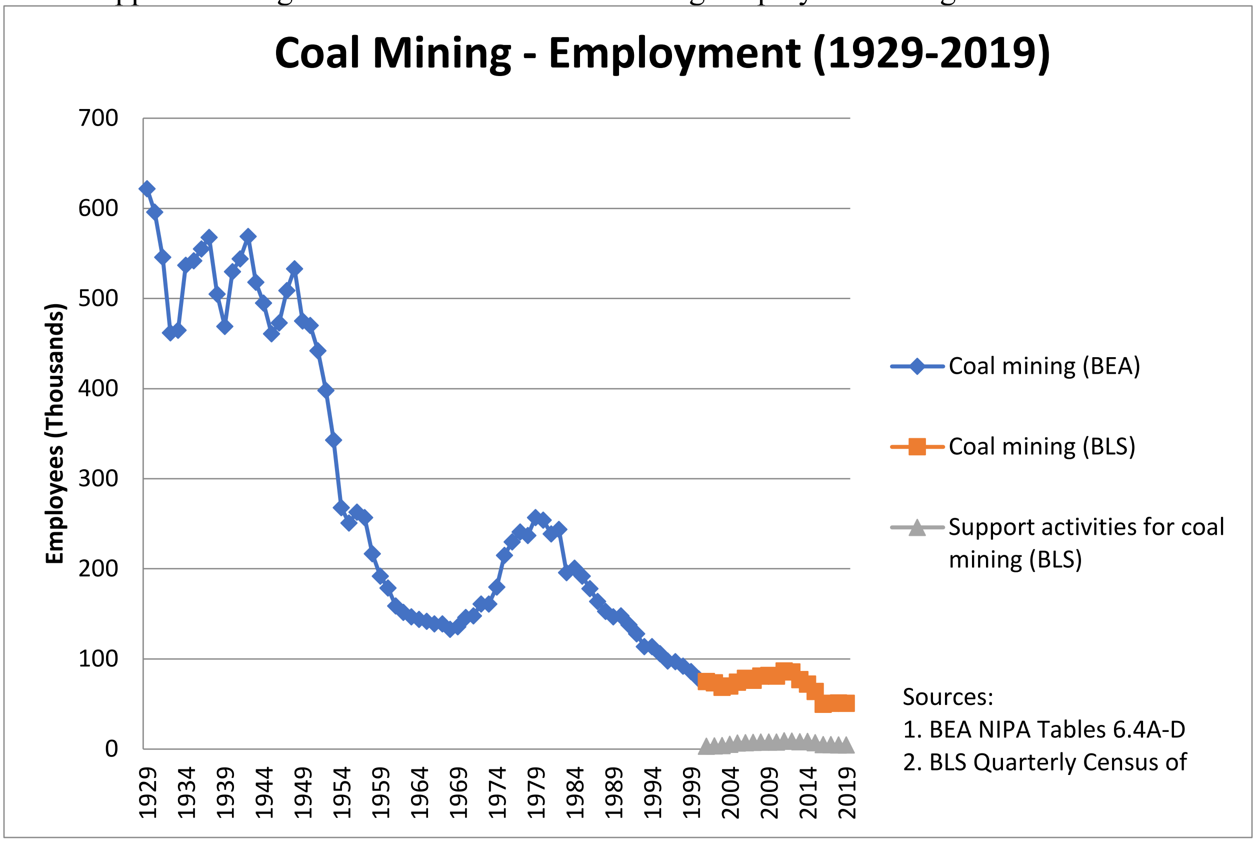
Std. dev. in parentheses and Robust t-statistics are in parentheses. The descriptive statistics are in levels, not in logs in the cases that the table states log in the variable names, though the regression results report the results using log as described in the empirical implementation section.
***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

Appendix 1 Figure 1: Coal Fields of the United States.



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 1 Figure 2: Annual U.S. Coal Mining Employment using BLS/BEA Data



Sources listed in figure.

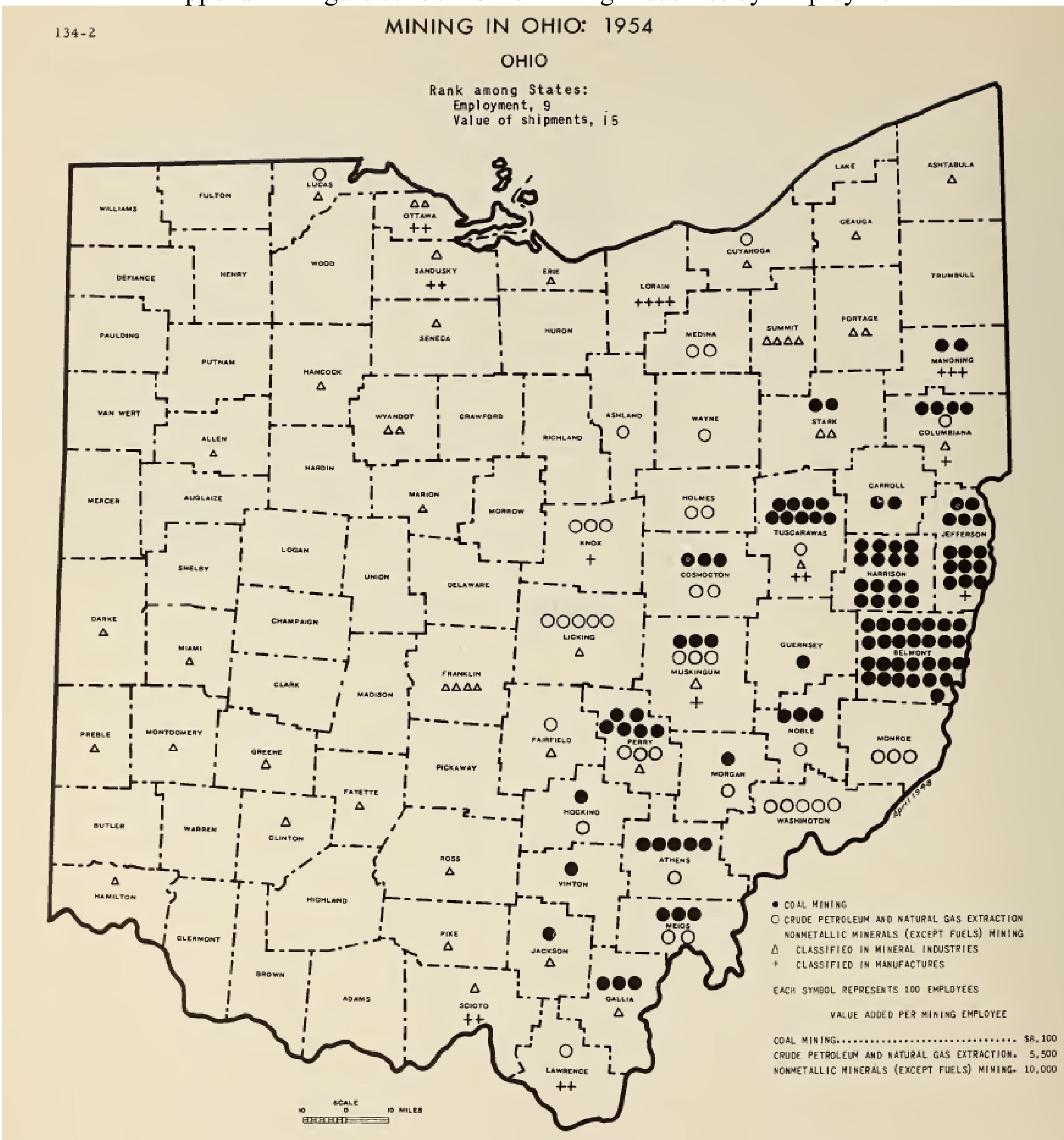
Appendix 1 Figure 3: 1954 Alabama Mining Industries by Employment

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 1 Figure 4: 1954 Kentucky Mining Industries by Employment

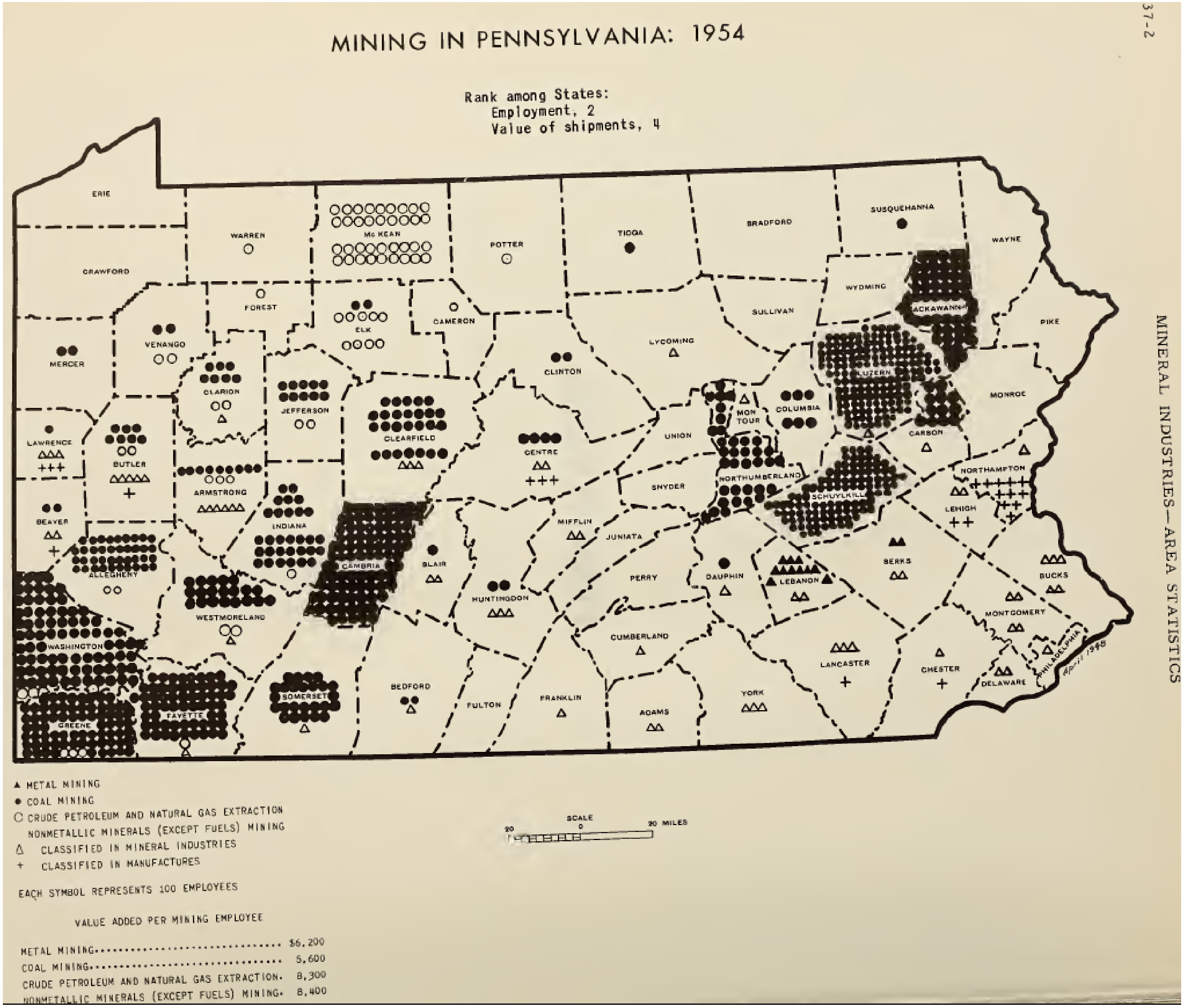
Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs.

Appendix 1 Figure 5: 1954 Ohio Mining Industries by Employment



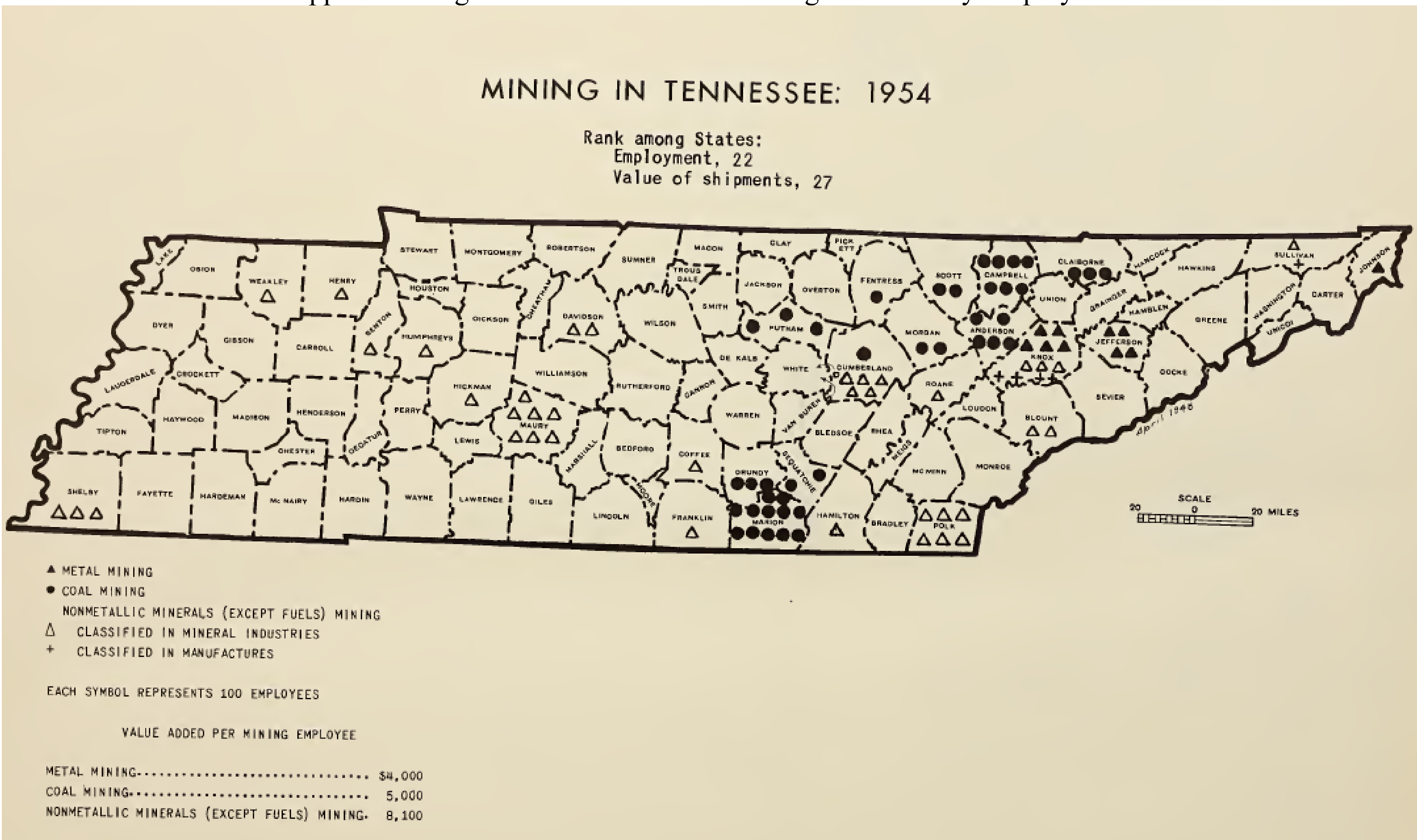
Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs.

Appendix 1 Figure 6: 1954 Pennsylvania Mining Industries by Employment



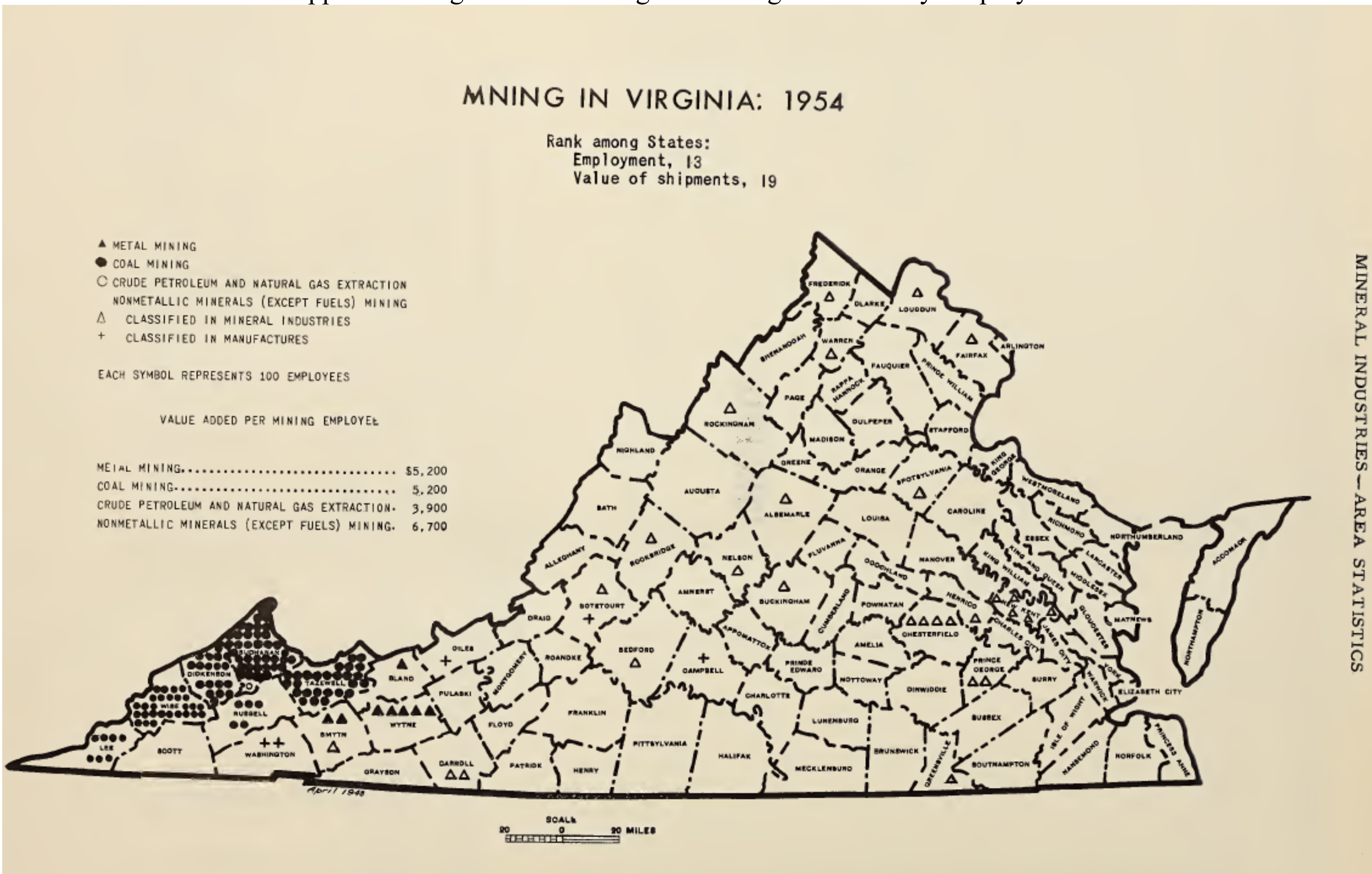
Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs.

Appendix 1 Figure 7: 1954 Tennessee Mining Industries by Employment



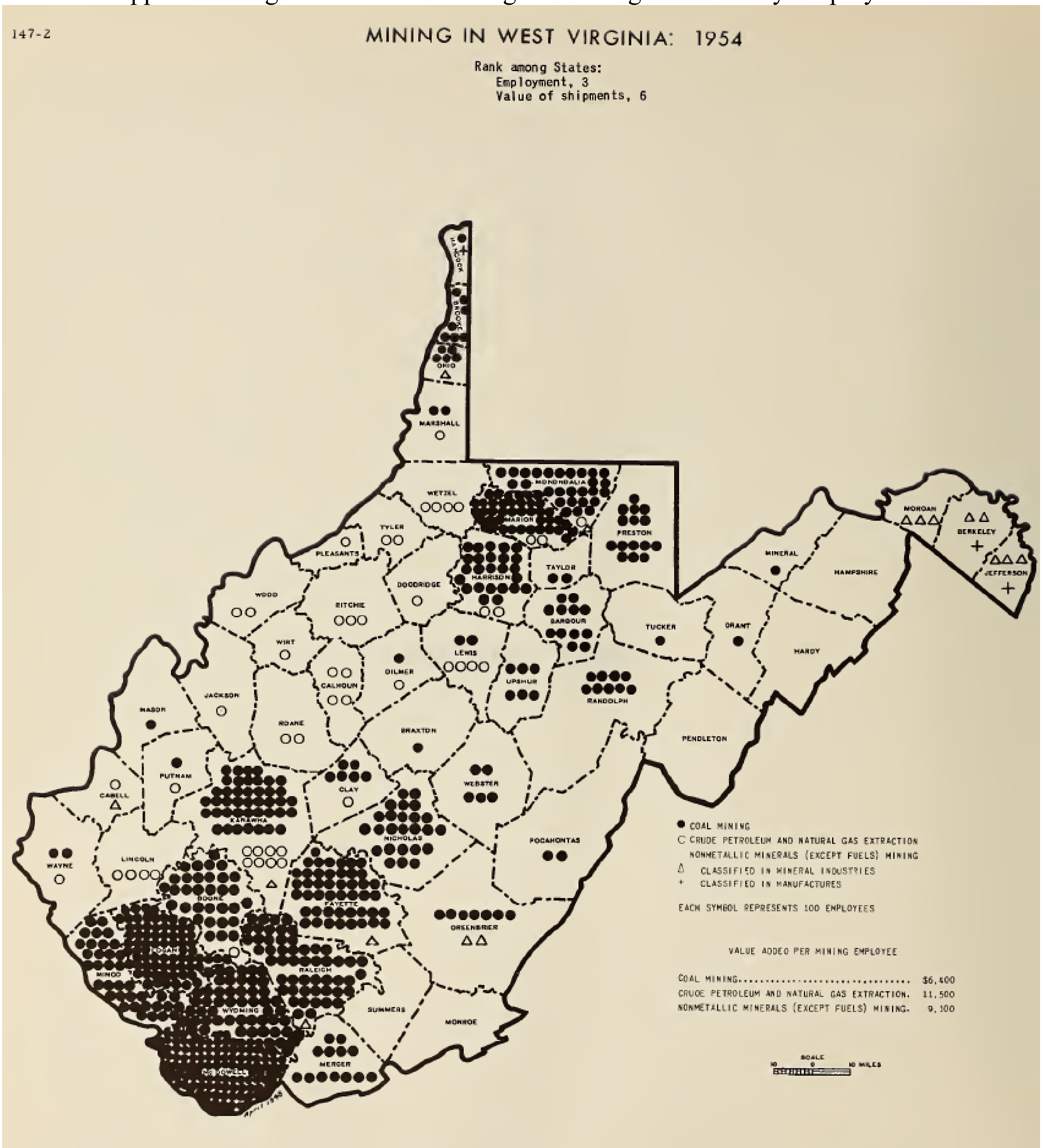
Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs.

Appendix 1 Figure 8: 1954 Virginia Mining Industries by Employment



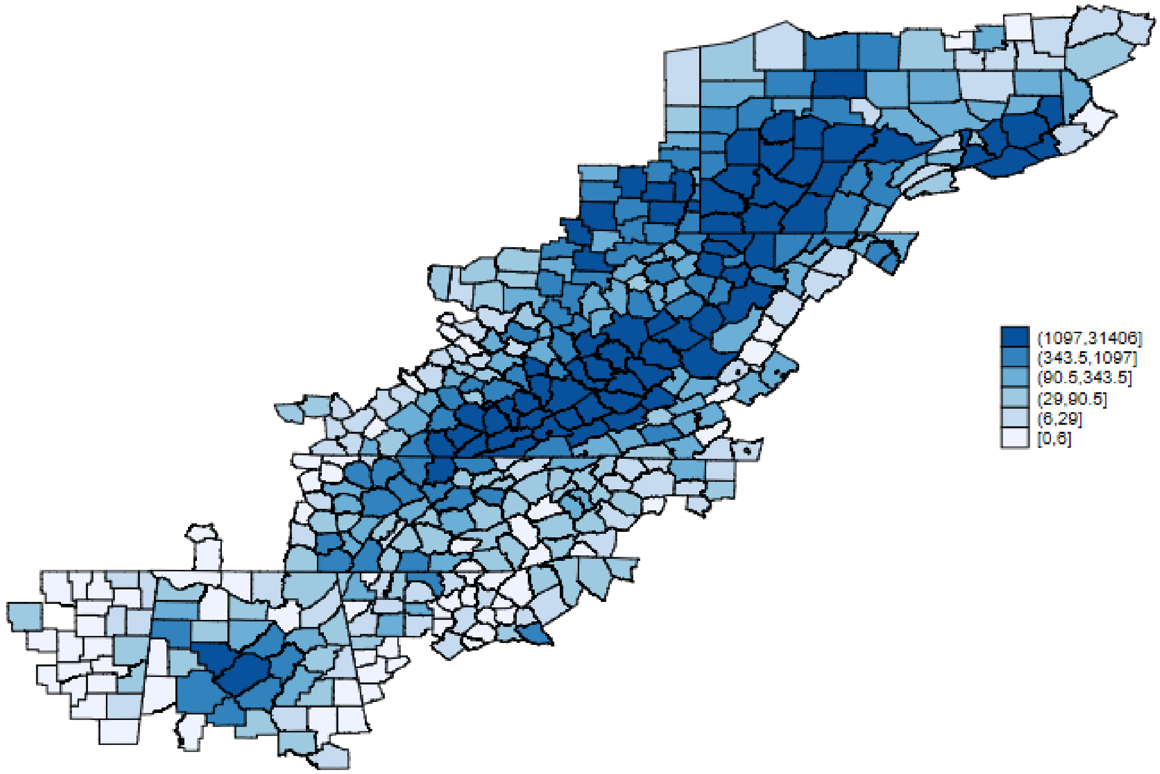
Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs

Appendix 1 Figure 9: 1954 West Virginia Mining Industries by Employment



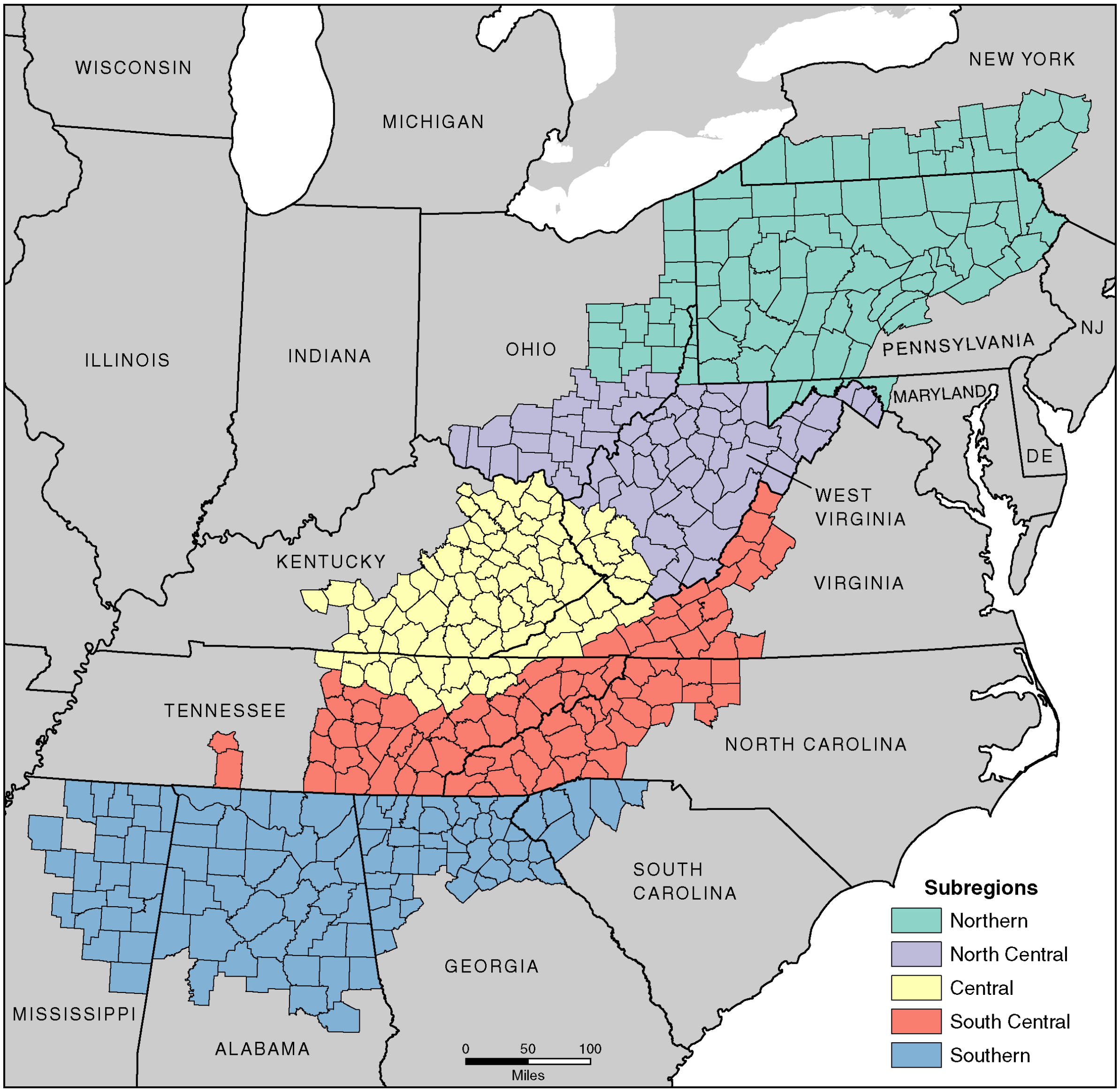
Source: Reproduced from 1954 Census of Manufacturing, Vol. 2. Each symbol represents 100 mining employees, e.g., Black circles denote 100 coal-mining jobs.

Appendix 1 Figure 10: 1950 Mining Workers by Place of Residence, ARC Counties



Source: 1950 Census of Population.

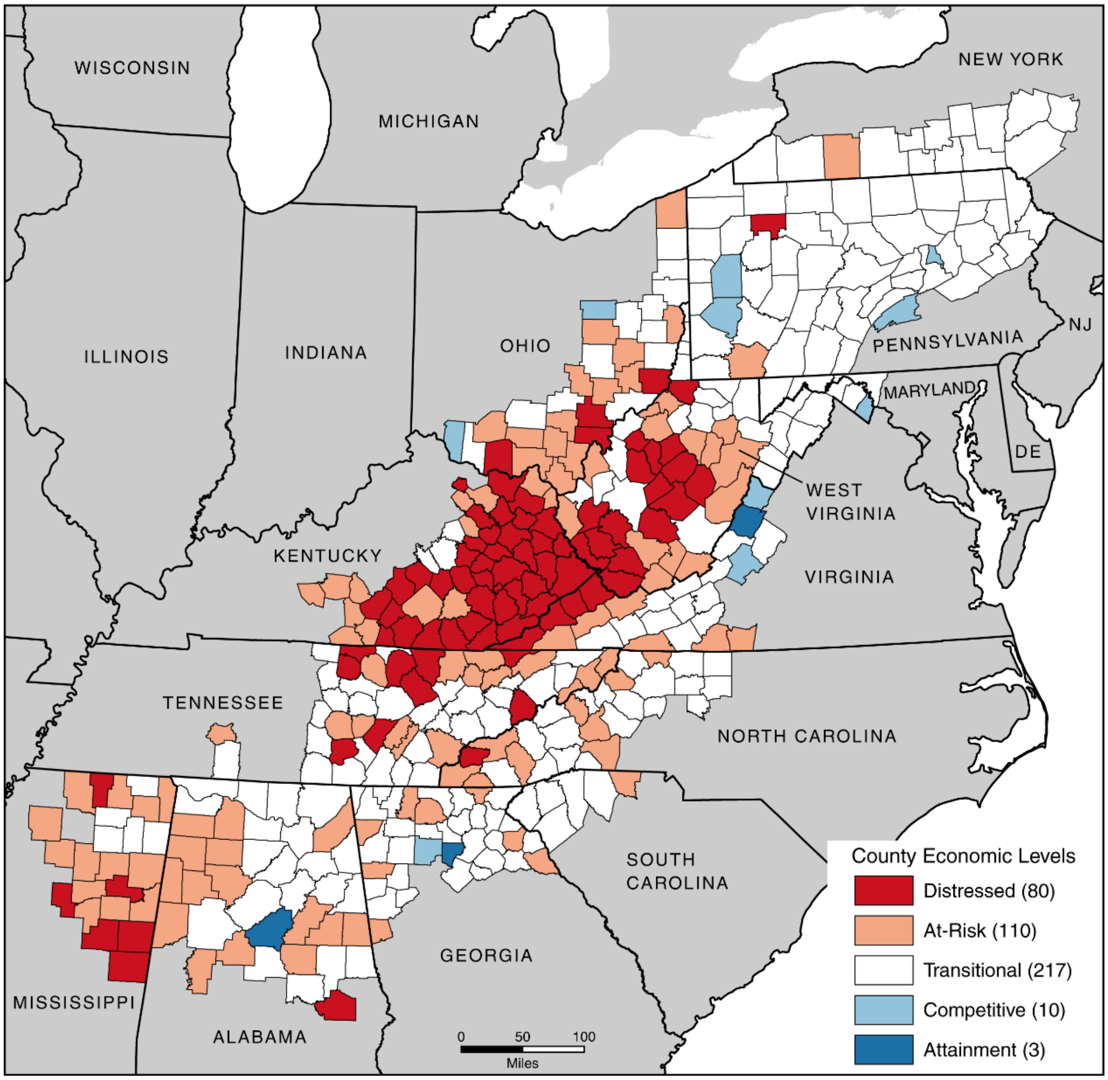
Appendix 1 Figure 11: ARC Defined Regions



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 1 Figure 12: ARC Distress Indicators of Economic Well-Being

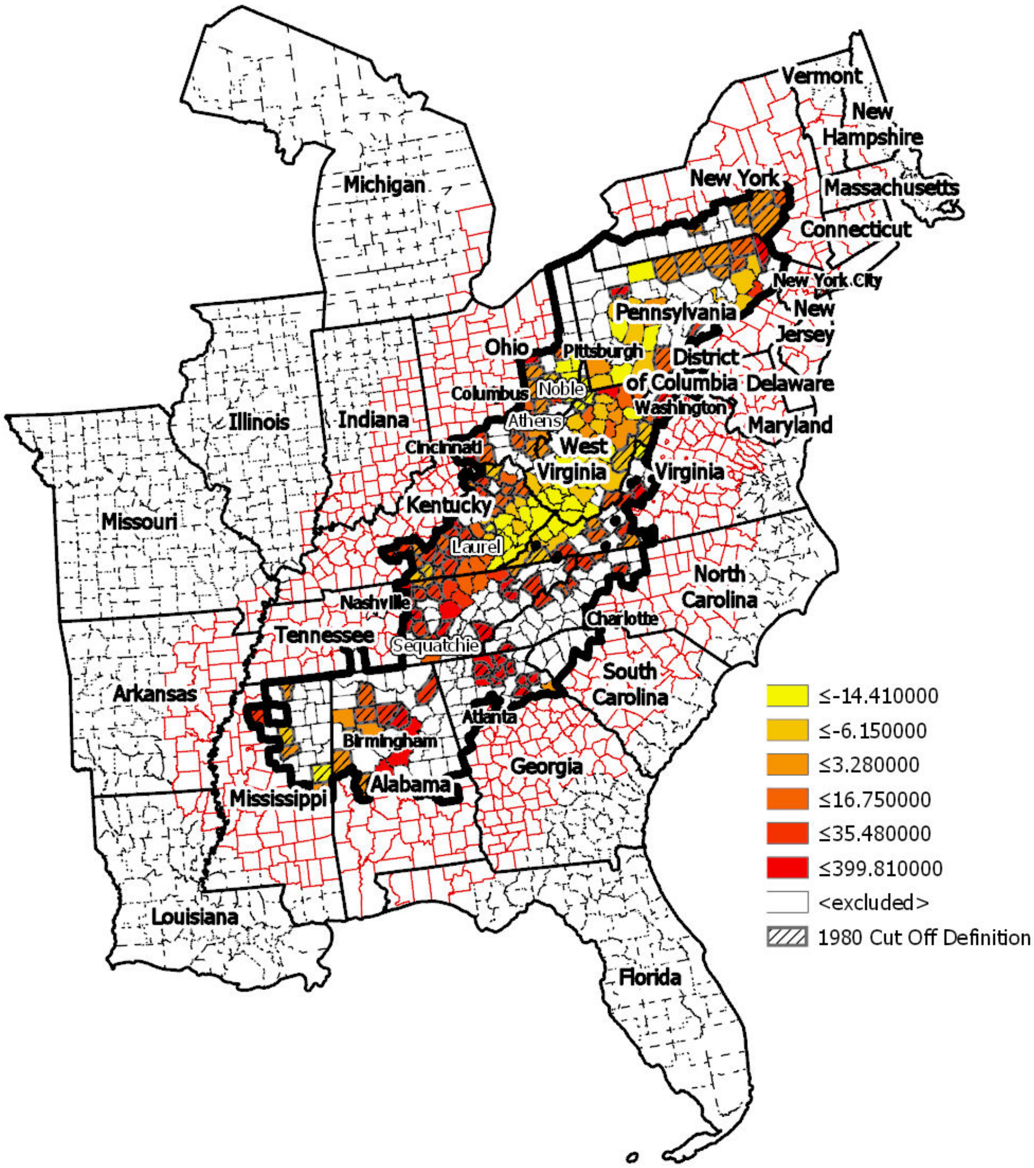


Created by the Appalachian Regional Commission, June 2019
Data Sources:
Unemployment data: U.S. Bureau of Labor Statistics, LAUS, 2015–2017
Income data: U.S. Bureau of Economic Analysis, REIS, 2017
Poverty data: U.S. Census Bureau, American Community Survey, 2013–2017

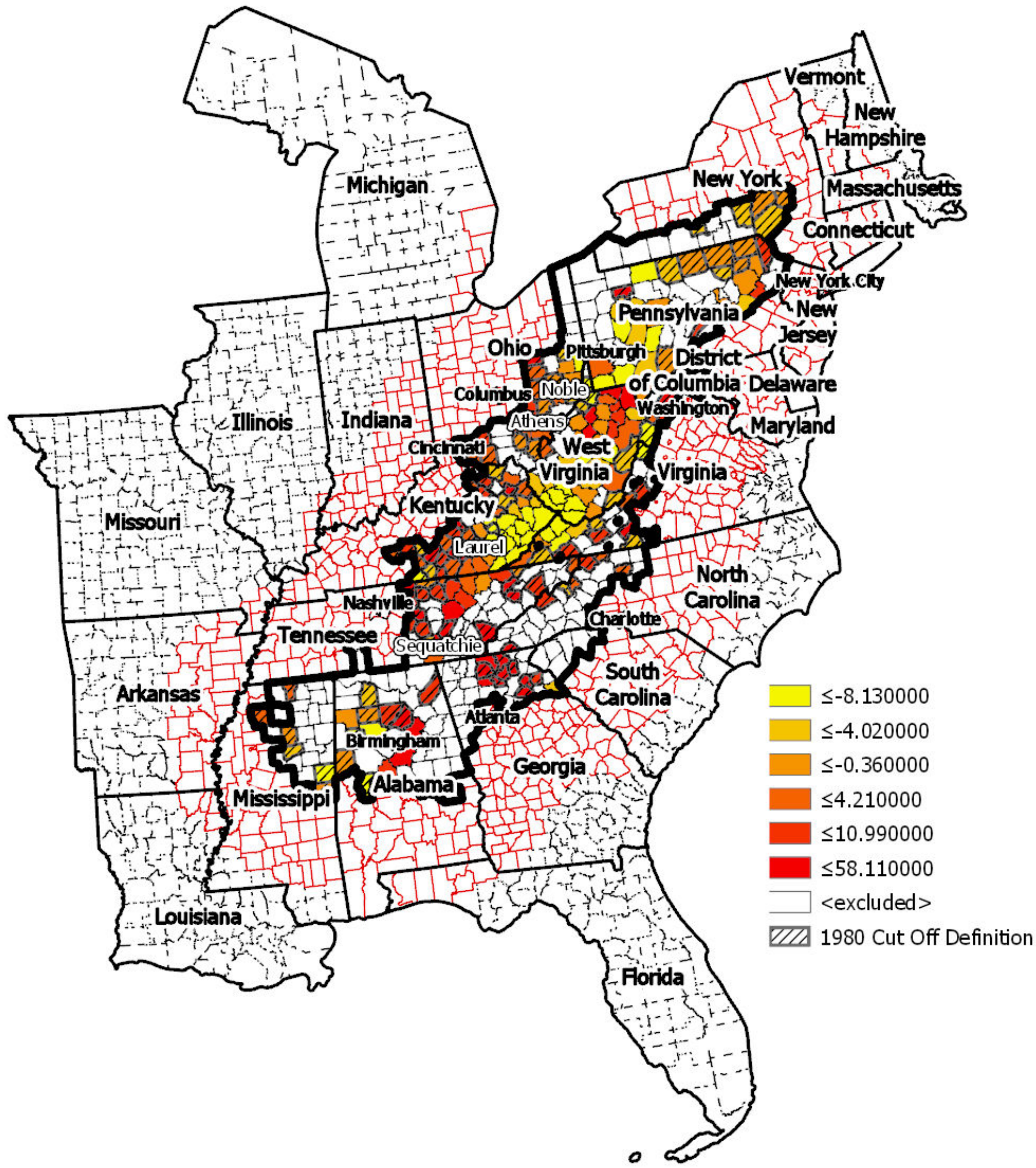
Effective October 1, 2019
through September 30, 2020

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 1 Figure 13: 1980-2018: ARC %Population Growth in 1950 and 1980 Mining-Intensive Counties



Appendix 1 Figure 14: 2000-2018: ARC %Population Growth in 1950 and 1980 Mining-Intensive Counties



APPENDIX 2: 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.

Appendix 2.1 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, is mainly published refereed articles from academic journals as well as reports from governmental and non-governmental agencies. Our findings are based on the 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 and 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.

Appendix 2.2 Classification of Studies.

In the Appendix 2 (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 – these typically involve 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 classifications for the thematic focus of studies. First, are studies focused on the impacts of employment by various industries (e.g., coal mining, oil and gas mining) on community well-being. The next classification of studies is event-based studies which focus on the impacts of temporal changes in global or local economy (e.g., various shocks and boom and bust cycles) on community well-being. The last major category of studies includes studies focused on policies implementation – both planning for future implementation and evaluating policies previously applied.

The third classification of studies is based on the impact or outcome variable(s) examined by the reviewed literature. The first, and most common of the outcomes explored were those on communities' socioeconomic well-being which included indicators such as poverty rates, employment rates, median household income, etc. A second category 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 category of outcomes explored were the extent to which policy interventions and implementations accomplished their intended goals.

The final classification denotes the factors that mattered in affecting the outcome variable(s) and includes either opportunities or barriers. Opportunities include those factors found to have positive impacts and/or improve community well-being; whereas, 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).

Appendix 2.3 Overview of Table Sections. (see above for elaboration)

- **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 2 Table 1: Targeted Literature Review, Table of Findings

Citation	Methodology	Focus of Studies	Community Impact or Outcome Variable(s)	What Mattered?
Appalachian Citizens' Law Center et al. 2019. "A New Horizon: Innovative Reclamation for a Just Transition."	20 case-study communities in Virginia, West Virginia, Kentucky, and Ohio **Policy evaluation**	**Policy:** assessing the impacts of Abandoned Mine Lands recovery projects	**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)	**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.
BenDor, Todd K. et al. 2015. "Defining and Evaluating the Ecological Restoration Economy: Defining and Evaluating the Restoration Economy."	14 case-studies of restoration projects at national, state, and county levels **Systematic literature review**	**Employment by industry:** restoration economy	**Socio-economic well-being:** employment multiplier effects of the restoration economy.	**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
Besser, Terry L. et al. 2008. "The	99 small towns in Iowa	**Event:** community economic shocks	**Socio-economic well-being**: Quality of Life (QoL)	**Opportunities**

Impact of Economic Shocks on Quality of Life and Social Capital in Small Towns."	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**	(e.g., loss of major employer, opening of new prison, boom and bust from energy development, natural disasters)	• 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	• 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.*
Betz, Michael et al. 2015. "Coal mining, economic development, and the natural resource curse."	Continental U.S. counties & separate counties within the Appalachian Regional Commission (ARC) borders for two time periods: 1990-2000 and 2000-2010.	**Employment by industry:** total county coal mining employment share and the impact on community well-being indicators	**Socio-economic well-being:** percent changes for the decadal models (1990-2000 and 2000-2010): 1. Per capita income 2. Wage and salary income	**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

	Quantitative empirical analysis of secondary data		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.	• 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.
Black, Dan, et al. 2005. "The Economic Impact	Counties in Kentucky, Ohio, Pennsylvania, and West Virginia	**Employment by industry & event:** coal mining,	**Socio-economic well-being:** (1) Employment Multipliers: jobs	**Opportunities:** • Coal boom spurred economic growth in the non-mining

of the Coal Boom and Bust."	Boom-bust cycle in 1970-1980s: Boom, 1970-7 Peak, 1978-82 Bust, 1983-9 **Quantitative empirical analysis of secondary data**	employment, and earnings per mining worker and the impact on community well-being across boom-bust cycles	created in traded or local sector per job created in mining sector (2) Wage growth by sector, 1970-80 & 1980-90 a. Mining b. Non-Mining c. Construction d. Retail Trade e. Services f. 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.	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 ever 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.
Carley, Sanya, et al. 2018. "Adaptation, Culture, and the Energy Transition in American Coal Country."	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**	**Event:** coal mining communities' perceptions and acceptance of transition away from coal.	**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	**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.

Chamberlin, Molly et al. 2019. "Success Factors, Challenges, and Early Impacts of the POWER Initiative: An Implementation Evaluation."	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**	**Policy:** POWER initiative – an evaluation of 88 projects and whether they met their shared objectives of projects.	**Socio-economic well-being**: (1) Economic Diversification (2) Job Creation (3) Capital Investment (4) Workforce Development (5) Reemployment	**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
Cook, Ak. 1995. "Increasing Poverty in Timber-Dependent Areas in Western Washington."	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**	**Employment by industry:** timber-dependent employment (forestry/fisheries and furniture, lumber and wood products).	**Socio-economic well-being:** poverty rates	**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.

Cowan, Tadlock. 2012. Military Base Closures: Socioeconomic Impacts.	Communities/localities with military bases **Systematic literature review**	**Event:** military base closures (BRAC)	**Socio-economic well-being:** employment multipliers & income multipliers Input-Output analyses	**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.
Daniels, S.E., et al. 2000. "Reemployment Programs for Dislocated Timber Workers: Lessons from Oregon."	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	**Policy:** reemployment programs for Displaced Timber Workers	**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*	**Opportunities** • Both programs produced modest, positive effects on the displaced workers' job satisfaction **Barriers** • Challenges to starting small business in nascent industry (ecosystem restoration)

	(2) Benton County – more diversified economy based on timber and wood products Assessment of 2 worker training programs **Qualitative empirical analysis & policy evaluation**		*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.*	
Deaton, James B., et al. 2012. "An Empirical Examination of the Relationship between Mining Employment and Poverty in the Appalachian Region."	399 Counties in Appalachia (ARC) **Quantitative empirical analysis of secondary data**	**Employment by industry:** mining employment	**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.	**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 (+) **
Douglas, Stratford and Anne Walker. 2017. "Coal Mining and the Resource Curse in the Eastern United States."	409 Appalachian Counties (1970-2010): Compare coal counties to coal-free counties **Quantitative empirical analysis of secondary data**	**Employment by industry:** resource-sector dependence as measured by employment in coal mining	**Socio-economic well-being:** long-run (1970-2010) per capita personal income growth	**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
Freudenburg, William R., and Lisa J. Wilson. 2002. "Mining the Data: Analyzing the	Meta-analysis of all quantitative studies on mining (301) comparing nonmetropolitan mining regions compared against other nonmetro regions	**Employment by industry:** mining and mining dependence	**Socio-economic well-being:** 1. Income 2. Poverty 3. Unemployment 4. Overall Findings	**Barriers** • Mining has predominantly *adverse* for unemployment, poverty, and overall findings • Findings of favorable economic conditions in mining

Economic Implications of Mining for Nonmetropolitan Regions."	and/or their own experiences over time. **Systematic literature review**			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
Graff, Michelle, et al. 2018. "Stakeholder Perceptions of the United States Energy Transition: Local-Level Dynamics and Community Responses to National Politics and Policy."	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	**Employment by industry:** sectors related to energy transition: 1. Automobiles 2. Coal company headquarters and coal railroad hub 3. Coal mining	**Policy evaluations:** 1. Community Activities related to Transition 2. Actors and institutions across communities leading (or not) on energy policy issues	**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

	Country (Counties in KY and WV) **Qualitative empirical analysis**			○ 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
Greenberg, Pierce. 2018. "Coal Waste, Socioeconomic Change, and Environmental Inequality in Appalachia: Implications for a Just Transition in Coal Country."	Neighborhoods (Census tracts) in Central and North Central Appalachian Region between 1990-2000 **Quantitative empirical analysis of secondary data**	**Employment by industry:** Coal waste impoundments (negative environmental externality of mining)	**Socio-economic well-being:** change in poverty rate from 1990-2000	**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.
Haggerty, Julia H., et al. 2018. "Planning for the Local Impacts of Coal Facility Closure: Emerging Strategies in the U.S. West."	Characterization and assessment of strategies of local governments policies surrounding the closing of coal-fired plants in the U.S. West. **Systematic literature review**	**Employment by industry:** coal-fired power plants	**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	**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,

			with community resilience during transitions	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
Haggerty, Julia. 2014. "Long-Term Effects of Income Specialization in Oil and Gas Extraction: The U.S. West, 1980-2011."	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**	**Employment by industry & event:** oil and gas specialization	**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	**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

			11. Violent and property crimes per 1000 people* *only three found to be statistically associated with the duration of oil and gas development.	
Haggerty, Mark. 2019. "Communities at Risk from Closing Coal Plants."	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**	**Employment by industry:** coal plants	**Policy evaluations:** vulnerabilities and barriers to transition	**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
				    o 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
				    o 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
Haller, Melissa, et al. 2017. “The End of the Nuclear Era: Nuclear Decommissioning and Its Economic Impacts on U.S. Counties.”	County level study of 24 nuclear reactors that have undergone decommissioning from 1975-2014. **Quantitative empirical analysis of secondary data**	**Event:** nuclear decommissioning	**Socio-economic well-being:** 1. Employment 2. Income 3. Population Method – Difference-in-difference regression Propensity score matching	**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
Hooker, Mark A. and Michael M. Knetter. 2001. “Measuring the Economic Effects	57 counties with military bases experiencing closures	**Event:** Military base closures	**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	**Opportunities** • Military base closures had (+) job multiplier effects, likely due to: • Counties receiving technical and financial aid in their reuse

of Military Base Closures.”	**Quantitative empirical analysis of secondary data**			(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.
Hultquist, Andy and Tricia L. Petras. 2012. “An Examination of the Local Economic Impacts of Military Base Closures.”	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**	**Event:** Military base closures	**Socio-economic well-being:** Total employment	**Opportunities** • Places with higher military base personal (own county) prior to the closure of a base experienced (+) * change in county employment
Isserman, Andrew M., et al. 2007. “Why Some Rural Communities Prosper While Others Do Not.”	All rural counties in the continental U.S. **Quantitative empirical analysis of secondary data**	**Employment by industry:** Attributes of *Prosperous* rural counties	**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)	**Opportunities** • **Geographic Indicators:** o 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.

			Findings based on t-tests**	• **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
Jolley, Jason, et al. 2019. "The economic, fiscal, and workforce impacts of coal-fired power plant closures in Appalachia Ohio."	Adams county, OH – two Dayton power & light coal-fired power plants (in Appalachia Region) **Quantitative empirical analysis of secondary data**	**Employment by industry:** coal-power plants	**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	**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
Kelsey, Timothy, et al. 2016. "Unconventional Gas and Oil Development in the United States: Economic Experience and Policy Issues."	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**	**Event:** gas and oil development	**Policy evaluations:** recommendations and implementation	**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
Kirschner, Annabel R. 2010. "Understanding Poverty and Unemployment on the Olympic Peninsula after the Spotted Owl."	Sub-county areas formed from census tracts in the Olympic Peninsula of Washington State **Quantitative empirical analysis of secondary data**	**Employment by industry:** timber and timber dependency	**Socio-economic well-being:** 1. Poverty (2000) 2. Unemployment (2000)	**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
Lobao, Linda, et al. 2016. "Poverty, Place, and Coal Employment across Appalachia and the United States	Counties across the US as well as specifically in Appalachian region (ARC) from 1990 to 2010.	**Employment by industry:** coal mining employment and change in coal mining employment	**Socio-economic well-being:** 1. Poverty 2. Household income 3. Unemployment	**Opportunities** • **Poverty** ○ Coal employment (-) * from 2000-2010 for US and ARC ○ Share oil and gas employment (-) * 2000-2010 for all US counties

in the New Economic Era."	**Quantitative empirical analysis of secondary data**			o Growth in coal employment (-) * for ARC in both periods • **Median Household Income** o Share coal employment (+) * in US and ARC for 2000-10 period o Oil and gas mining employment (+) * for US in 00-10' • **Unemployment** o Coal employment (-) * for US and ARC in 00-10' period o Gas and oil employment (-) * for US in 00-10' period o Change in other mining employment for US and ARC in 90-00' and 00-10' o Change in employment for coal (-) * for US and ARC in 00-10' o Change in employment for oil and gas (-) * for US and ARC in 00-10' **Barriers** • **Poverty** o Higher coal employment (+) * 1990-2000 for US • **Median Household Income** o 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
Mayer, Adam. 2018. "A Just Transition for Coal Miners? Community Identity and Support from Local Policy Actors."	County and city policy actors in Colorado and Utah **Quantitative empirical analysis of survey data**	**Employment by industry:** coal mining	**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?	**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

Partridge, Mark D. et al. 2013. “Natural Resource Curse and Poverty in Appalachia America.”	Counties in Appalachia region (ARC) over the 1990-2010 period. **Quantitative empirical analysis of secondary data**	**Employment by industry:** coal mining employment & mountain top mining	**Socio-economic well-being:** poverty rates (2000)	**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 (-) *
Partridge, Mark D. and M. Rose Olfert. 2011. “The Winners’ Choice: Sustainable Economic Strategies for Successful 21st-Century Regions.”	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**	**Employment by industry:** general indicators of growth	**Socio-economic well-being:** population growth (size and density) as well as urbanization intensity	**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

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."	National overview of potential framework for transitioning communities and workers away from fossil fuel based employment. **Systematic literature review**	**Employment by industry:** fossil-fuel dependent employment	**Policy evaluations:** transitioning workers away from coal employment	**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
Poppert, Patrick E. and Henry W. Herzog Jr. 2003. "Force Reduction, base closure, and the indirect effects of military installation on	3092 counties in the United States **Quantitative empirical analysis of secondary data**	**Event:** military base closures	**Socio-economic well-being:** employment in private, nonfarm sectors	**Opportunities** • Military base closures show (+) * on employment two years after base closure • Transfers for educational assistance (+) * on employment rates

local employment growth."				• 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
Snyder, Brian F. 2018. "Vulnerability to Decarbonization in Hydrocarbon-Intensive Counties in the United States: A Just Transition to	Community level overview of the development of a metric to assess vulnerabilities/resiliencies to decarbonization of the economy to develop an index of vulnerability	**Employment by industry:** hydrocarbon dependent occupations	**Socio-economic well-being:** vulnerability Index – to assess areas vulnerable to socioeconomic declines due to decarbonization	**Barriers** • Geographic isolation • High-levels of preexisting socioeconomic disadvantage • Large levels of hydrocarbon employment • Low educational levels may negatively impact communities' ability to adapt

Avoid Post-Industrial Decay.”	**Quantitative empirical analysis of secondary data**			• 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.
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.”	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**	**Event:** military base closures	**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	**Barriers** • Counties with military base closures (-) * employment levels relative to those without • Counties with military base closures experienced (-) * population growth compared to those without
Tsvetkova, Alexandra and Mark D. Partridge. 2016. “Economics of Modern Energy Boomtowns: Do Oil and Gas Shocks Differ from Shocks in	Counties **Quantitative empirical analysis of secondary data**	**Employment by industry:** oil and gas	**Socio-economic well-being:** (1) Employment across 14 sectors (2) Population size	**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

the Rest of the Economy?”				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.
Tsvetkova, Alexandra, et al. 2019. “Self-Employment effects on regional growth: a bigger bang for a buck?”	Counties (2001-2013) **Quantitative empirical analysis of secondary data**	**Employment by industry:** self-employment vs. wage/salary employment	**Socio-economic well-being:** employment growth rates	**Opportunities** • Estimated benefits for self-employment on employment growth rates (+) * are substantially larger than identical effects of paid employment
Weinstein, Amanda L., et al. 2018. “Follow the money: aggregate, sectoral and spatial effects of an energy boom on local earnings.”	Counties by metro and nonmetro status that experience energy expansion compared to other areas **Quantitative empirical analysis of secondary data**	**Employment by industry:** oil and gas	**Socio-economic well-being:** (1) Change in total earnings growth (2) Change in Earnings per worker growth (3) Change in employment growth	**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 (-) *
Weber, Jeremy G. 2012. "The Effects of a Natural Gas Boom on Employment and Income in Colorado, Texas, and Wyoming."	Counties in Colorado, Texas and Wyoming through boom and bust cycles of natural gas extraction **Quantitative empirical analysis of secondary data**	**Employment by industry & event:** natural gas	**Socio-economic well-being:** (1) Employment (2) Wage and salary income (3) Median household income (4) Poverty	**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 (-) *

Appendix 2.4 List of Studies Cited in Table.

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