Spatial Analysis of Economic Recovery in Appalachia in the Post-Recession Period

A Senior Capstone Experience

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Abstract: This study describes how economic trends in Appalachia from 2007 to 2019 differed from the nation during an unprecedented period of economic expansion. We used summary statistics to compare trends in unemployment, per capita market income, and poverty in the Appalachian region with the United States as a whole. We found that Appalachia performed worse than the rest of the nation in all indicators. We also used spatial statistics to examine the spatial distribution of values for economic indicators within Appalachia and found that central Appalachia performed consistently worse than the northeast. Job gains in the south have not led to increases in income for that region. Additional research into causes for these economic disparities is needed.

Keywords: Appalachia, 2008 Recession, Economic Recovery, Transportation Infrastructure, Regional Economic Development

SPATIAL ANAYSIS OF THE APPALACHIAN ECONOMIC RECOVERY

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Chapter 1: Introduction

The American economy experienced its longest expansion from the end of the Great Recession in 2009 until the recent economic downturn in response to the COVID-19 pandemic. However, not all regions shared equally in this decade of economic growth. Mountainous Appalachia, which stretches from New York to Mississippi, has historically performed worse than the rest of the nation in socioeconomic measures, including income, poverty, unemployment, and educational attainment. Health outcomes for Appalachia are also worse than the national average with higher rates of cancer, heart disease, and diabetes. The region experiences higher than average outmigration rates. Between 2000 and 2010, 64.5% of Appalachian counties experienced net population loss (ARC 2011). In many ways, the gap between Appalachia and the rest of the United States has been made apparent since the end of the Great Recession.

Many economists have sought to explain why these disparities exist. One prevalent theory is that the geographic features of this region create isolated communities with limited market access. Transportation costs are particularly high in terms of both time and distance because of the mountainous terrain. The cost of building roads in Appalachia is also high due to environmental and topographical factors, which is one reason the region has been largely bypassed by the interstate highway system (EDRG 2017). High transportation costs inhibit the movement of labor and capital and limit access to markets. Market access typically refers to the ability of firms to enter new international markets; however, the model can be applied to interregional trade. At the regional level, market access includes the ability of firms to connect with labor, suppliers, and markets to sell goods and services. For individuals, the ability to reach employers, medical care, retailers, and other services can be considered part of regional market access. Theory suggests that increasing access to markets should stimulate economic growth.

Another theory which seeks to explain the relatively slow pace of economic growth in the region is that the economy has historically been dependent on extractive industries which have led to uneven growth and environmental degradation. In international development literature, the stunted economic development associated with the prevalence of extractive industries is known as the "natural resource curse." When a nation relies primarily on the extraction of a single natural resource for economic growth, employment in the natural resource sector is emphasized while education and development of other technologies and industries are neglected. Extractive industries are also associated with income inequality and the concentration of wealth among owners of extractive capital who engage in rent-seeking behavior (Collier 2007). This framework can be applied to Appalachia at the regional level, where natural resources such as timber, coal, and natural gas are extracted and sold or "exported" to the rest of the nation.

Appalachia is well known for its economic reliance on coal mining. Coal mining jobs were once highly sought after. Wages for miners were historically high, and mining is one of the most heavily unionized industries in Appalachia (Lobao et. al 2016). A 2005 study by Black, McKinnish, and Sanders found that for every 100 new jobs in the Appalachian coal industry, 25 jobs were indirectly created in other sectors through a multiplier effect. In the years leading up to the recession, job gains in mining were greater than any other single industry, accounting for 39.7% of employment growth (ARC 2011). The economic growth once fueled by coal has not proven to be sustainable, however.

In recent years, the future of the coal industry has been cast into doubt. National coal production decreased by 37% from 2008 to 2016 (Coglianese et. al 2020). There have been three main explanations for this dramatic decline in the coal industry. First, environmental regulations have increased the costs of compliance for coal-fired power plants. Second, natural gas has

become a relatively cheaper energy alternative because of the emergence of hydraulic fracturing technology. Finally, substitution away from coal in favor of renewable energy sources like wind and solar may have contributed to the decline in the coal industry. Coglianese, Gerarden, and Stock find that the relative decline in the price of natural gas accounts for 92% of the decline in coal production (2020). Whatever the cause, the Appalachian economy will depend on developing alternative industries in the future.

The President's Appalachian Regional Commission was established to investigate socioeconomic disparities in Appalachia and to create a plan for fostering economic growth in the region under the direction of President John F. Kennedy in 1963. A permanent commission to facilitate a "comprehensive program for the economic development of the Appalachian Region" was established in 1965. The Appalachian Regional Commission (ARC) was tasked with improving infrastructure, encouraging diversification of the economy, and making Appalachian industries competitive with the rest of the nation and the world (Appalachian Regional Development Act 1965). The largest component of total ARC spending is the Appalachian Development Highway System (ADHS), which was conceptualized to accomplish the goals of reducing Appalachian isolation and promoting industry.

As of fiscal year 2018, 2,796.8 miles of ADHS highways were open to traffic or currently under construction (ARC 2018). A total of 3,090 miles are planned for construction by 2040 for an estimated cost of $11.4 billion (ARC 2012). Reports commissioned by the ARC have claimed the ADHS has created 168,000 jobs and an additional $11 billion a year in gross regional product due to increased access to both national and international markets and lower transportation costs (EDRG 2016, EDRG 2017, Network Appalachia Study Group 2007, Wilbur Smith and Associates 1998). The data on the impact of the ADHS on the Appalachian economy

have been mixed, largely due to the difficulties of isolating the effects of the highway system from other gains in productivity. Various approaches to studying the economic impact of the ADHS will be discussed in the literature review in chapter 2.

The Economic Development Research Group (EDRG) finds that the ADHS contributed to growth in tourism and hospitality industries by increasing the accessibility of remote Appalachian counties rich in natural capital. They also theorize that the ADHS historically enabled growth in extractive industries by reducing transportation costs (EDRG 2007). Because the effects of the ADHS on the Appalachian regional economy cannot be measured directly, researchers turn to quasi-experimental methods. A study by Isserman and Rephann (1995) finds that incomes rose faster in Appalachia than in the rest of the nation in the first 25 years of the ARC based on a twin-counties approach. They compared changes in income in 391 counties in Appalachia with changes in incomes in counties with similar initial conditions in the rest of the country. Studies supporting the claims that the ADHS has substantially contributed to economic growth in Appalachia have done little to account for short-term job growth directly related to highway construction versus long term job growth.

Critics of the ARC argue that the commission's spending has not been prioritized to aid the counties that need aid the most; rather, it has been directed toward counties that are most effective at lobbying for assistance (Hall 2014). They also argue that the ADHS lacks a clear economic development strategy, that locations for ADHS construction were chosen without considering the economic potential of the areas the new roads would serve, and that jobs created are largely due to the construction jobs directly created from ADHS construction, which are short term (Widner 1973, Hansen 1966, Munro 1969). Critics also note that Appalachia remains behind the nation in many social and economic indicators today, 65 years after the ARC was

created (Hall 2014). Considering the contradictory findings on the effectiveness of the ADHS, this study aims to contribute empirical evidence to evaluate the role of the program in encouraging economic growth in Appalachia.

In this study, we focus on the resiliency of the Appalachian economy from 2007 to 2019. The Great Recession began in the December of 2007 when the market for sub-prime mortgages crashed. The recession lasted through the June of 2009. The number of job losses during the recession offset all the new jobs created in the region from the previous eight years. The manufacturing industry experienced the greatest decline, accounting for 24.6% of all job losses in the region during the recession (ARC 2011). Per capita market income in Appalachia was only 75% of the national per capita market income in 2009, as demonstrated in Figure 1. Also note that in 2009, income for the region fell to its 2000 levels.

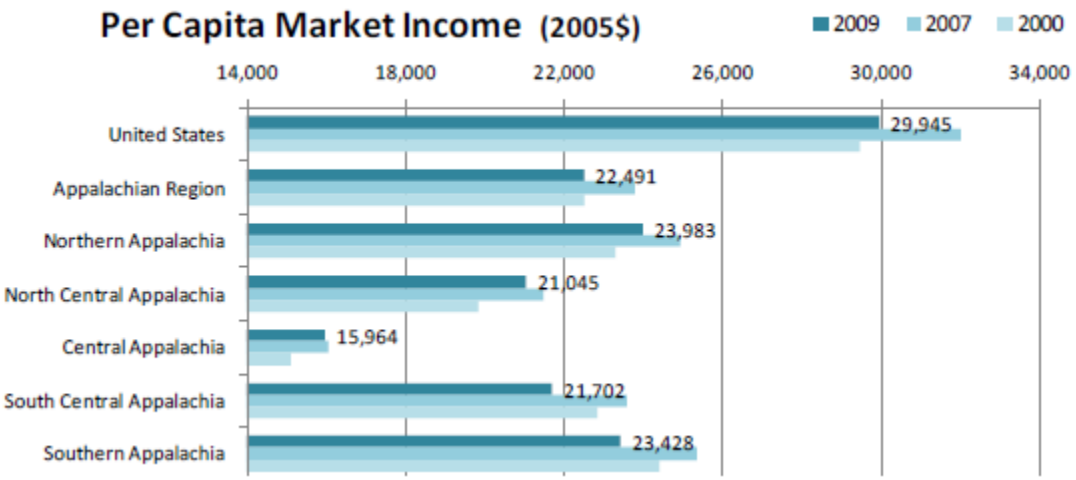

Figure 1: Per Capita Market Income in Appalachia. Source: Appalachian Regional Commission.

After the Great Recession ended, recovery in Appalachia was slow to start. From 2007 to 2010, only 8% of Appalachian counties experienced net positive job growth (ARC 2011). From 2007 to 2012, the Unites States as a whole experienced a 0.3% decline in jobs; the decline for Appalachia was 2.3%. Appalachian job growth from 2012 to 2017 was 4.7%, while the nation saw a more dramatic 9.6% increase in employment. Post-recession job growth has mostly

occurred in service industries including professional and technical services, health and social services, food, lodging and entertainment, and finance and real estate. The share of service industries in the Appalachian economy grew, while manufacturing and heavy industry declined (ARC 2019). The greatest growth occurred in industries with lower wages. The average worker in the food, lodging, and entertainment industry in Appalachia made $20,059 in 2017, while average earnings for regional workers in manufacturing were $58,113. Stimulating high-wage employment will be a challenge for the Appalachian region to overcome.

The data also demonstrate a rural-urban divide in recovery. Employment in metropolitan counties increased more than employment in rural counties. Large metropolitan areas with a population greater than one million experienced an employment growth of 8.3% which approached the national average for 2012 to 2017 of 9.6% employment growth. During the same time period, job growth in counties adjacent to metropolitan areas was approximately 2.5%. Rural employment experienced no net change (ARC 2019). The difference in employment growth in metropolitan areas and their neighbors may support the hypothesis that geographic isolation continues to inhibit economic growth in rural Appalachia.

With this evidence for slower economic recovery in Appalachia in mind, we seek to understand economic trends in Appalachia from 2007 to 2019 using summary statistics. We also use spatial analysis to compare economic indicators for counties in Appalachia that are a part of the ADHS system with those that are not. Chapter 2 summarizes existing research on the role of transportation in regional economies and geospatial approaches to analyzing economic growth. Chapter 3 gives an overview of the methods we used to address our research questions. Chapter 4 summarizes our findings on key trends in economic indicators. Chapter 5 describes the spatial

distribution of economic indicators. Chapter 6 concludes and looks to further research opportunities.

Chapter 2: Literature Review

Government spending on transportation infrastructure as a form of economic stimulus is well studied. Goetz (2011) analyzes the impact of transportation spending as part of the American Recovery and Reinvestment Act of 2009. He discusses direct benefits of transportation, which include construction jobs and savings on transportation costs, as well as indirect benefits like increasing volume of trade and the multiplier effect of government spending. Goetz describes measures used to quantify the extent and quality of road networks such as miles of roads, public spending on transportation infrastructure, and travel time costs. He also raises the question of bi-directionality between transportation network growth and economic growth; if the economy is strong, a high volume of trade will demand high-capacity road networks, and high-capacity road networks can make an increased volume of trade possible. This establishes an important consideration for any causal claims related to transportation and economic growth.

Goetz also gives an overview of three major approaches to understanding the interplay between transportation and economic growth. At the microeconomic level, the behavior of firms and consumers is affected by a benefit-cost analysis of transportation costs. At the macroeconomic level, spending on transportation is an investment in public infrastructure that can make an economy more productive. Finally, from a regional perspective, the volume of trade between regions will vary with the costs of transportation. Transport costs also contribute to the phenomenon of industrial clustering (Goetz 2011). McCann (2001) describes industrial clustering as the tendency for firms in the same industry to locate near each other. This may be

because they seek to establish themselves near input resources to decrease transportation costs. As firms in the same industry reach an economy of scale, a new market for specialized inputs to the industry also arises. The increasing specialization of labor and concentration of skilled workers in a particular industry makes the costs of recruiting workers lower for clustered firms. As transportation networks improve, the cost of transporting inputs to firms decreases, and firms are less constrained by proximity to inputs when choosing location.

The role of investment in transportation in macroeconomic growth at the regional level is central to this study. Measuring regional trade can be difficult since most indicators of economic activity, like gross domestic product, are collected at the national level. McCann (2001) writes that regional multiplier models are used as a proxy for regional trade data. The economic base model classifies industries as basic if they are export-oriented and non-basic if their output primarily serves local consumers. It assumes that total employment is a function of the ratio of employment in the basic versus non-basic sectors. If linkages between local firms are strong, then employment in the non-basic sector will be highly sensitive to changes in employment in the basic sector. Changes in employment in the basic sector are exogenously determined through supply and demand for exported goods and services. If transportation costs can be reduced through improved road networks, the supply of goods and services to be exported from the basic sector should increase, and employment in the basic sector increases. This results in a stimulation of the local economy through increased employment in the non-basic sector.

McCann also explains how the Keynesian theory of national income determination can be adapted to model regional income. Taxation at both the national and local levels must be accounted for. Government spending and investment in a regional model are dependent on regional income, while both variables are modelled exogenously at the national level. Regional

government spending is dependent on the likelihood for national government spending to change based on regional income. Likewise, the propensity for firms and households to invest locally versus nationally is included in the model. McCann argues that as regional income increases, the likelihood that firms and households will invest in the local regional economy increases (2001). The Keynesian regional multiplier model demonstrates government spending and private investment are endogenously determined at the regional level. Government spending on transportation infrastructure will be determined in-part by regional income.

The role of investment in transportation infrastructure in economic growth at the regional level is based on increased access to markets. Spatial analysis is a useful tool for understanding transportation costs and regional development. Existing research using geographic information systems (GIS) in Appalachian development includes tracking land use change over time by examining remotely sensed imagery from aerial photographs and satellite images. Patterns in land use change over time can indicate the growth and decline of agriculture versus industry. Where there are more impervious surfaces, anthropomorphic development has occurred. Changes in land use indicate changes in allocation of resources as a region develops.

Oliver and Thomas (2014) use the USDA's National Land Cover Database to examine differences in land use change in micropolitan statistical areas in Appalachia versus the rest of the United States. They found that micropolitan Appalachia was being developed more quickly than the national average for micropolitan areas from 2001-2006 and that land use change for micropolitan areas was substantially greater than for rural areas. Pockets of isolated rural areas experienced little land use change over the period of the study. Oliver and Thomas link land use change to population trends to explain patterns of urbanization, or a lack thereof, in Appalachia.

This research combines the use of satellite imagery with statistical analysis to compare rates of urbanization and development across different geographies and time periods.

GIS can also be used to conduct network analysis to understand access to markets. Network analysis is based on a model of line segments representing roads, called edges, and intersections between roads, called junctions. Both edges and junctions are coded with attributes such as speed limit, number of lanes, and other travel restrictions. Using algorithms to minimize transit costs in time or distance, network analysis identifies the shortest path between two points (Shellito 2012). Network analysis has been used to measure linkages with urban centers to determine access to markets for Appalachian counties. Partridge, Rickman, and Kamar (2008) find that as distance from urban areas increases, market potential decreases. They also find that costs of remoteness from urban centers in Appalachia have increased as access to information technology becomes increasing important for industry growth.

Alvarez-Ayuso, et al. (2016) use network analysis to model existing road infrastructure as public capital stock in a production function. They examine not only the market potential that road networks create through access to markets but also the actual commercial flow of goods and services roads enable. They model low-capacity roads within a region as internal capital stock, while high-capacity roads with connections to neighboring regions are modelled as imported stock. They conclude that geographic regions with a high imported stock of high-capacity roads export more goods to other regions and benefit from positive spillover effects.

Spatial analysis is also used to understand how population, migration, and economic performance measures are related, as well as how a shock to any of these factors in one county affects neighboring counties (Islam 2010, Patridge et al. 2008). Gebremariam, Gebremedhin, and Schaeffer (2011) model for measuring inter-county shocks using a Feasible Generalized Spatial

Three-Stage Least Squares Estimate. This method arranges data for each county in a matrix representing its actual position relative to neighboring counties and analyzes how changes to one county affect data values in neighboring counties in the matrix. These studies focus on isolation from markets as a barrier to development and the degree of interdependence between Appalachian counties.

Other studies analyze both the value and spatial distribution of data to identify clusters of geographies or outliers with values significantly above or below the average value. One method for conducting clustering and outlier analysis is Anselin Local Moran's I (Anselin and Kelejian, 1997). This study will use the Anselin Local Moran's I statistic function of ArcGIS Pro, a spatial analysis software program, to identify clusters of counties in Appalachia with per capita income, unemployment, and poverty statistics are significantly different from the average for the region. The relationship between the ADHS system and economic indicators in these counties will then be examined using summary statistics.

Chapter 3: Methodology

This study aims to describe trends in economic status of the 420 counties in the Appalachian Region from 2007-2019. The region, as defined by the Appalachian Regional Commission (ARC), ranges from New York to Mississippi along the Appalachian mountain range. These counties were partially determined by their geography, but also through lobbying for inclusion in the 1965 Appalachian Regional Development Act. Figure 2 shows the boundaries of the Appalachian Region for the purposes of this study.

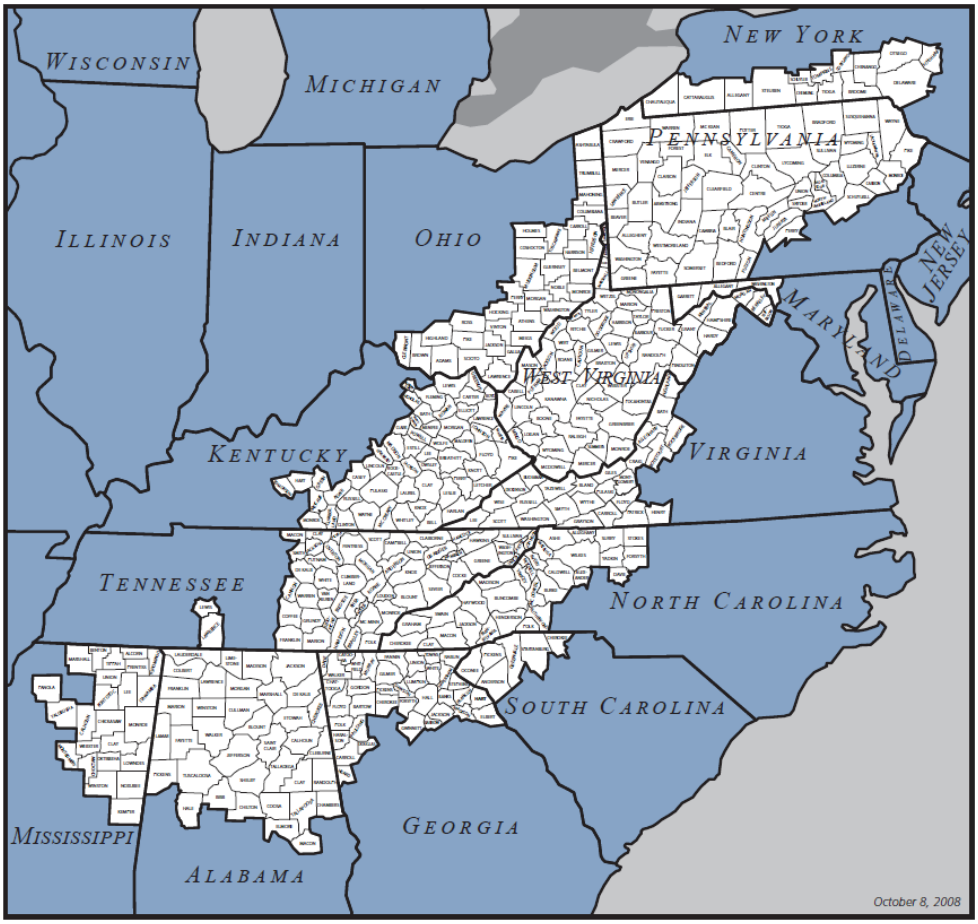

Figure 2: Map of Appalachian Region. Source: ARC.

The ARC uses a composite index to measure the economic conditions in Appalachian counties with the nation as a whole. Since 2007, this index has considered three-year average unemployment rates from the Bureau of Labor Statistics, per capita income as measured by the

Bureau of Economic Analysis, and five-year estimates of poverty rates from the American Community Survey. The ARC ranks each county in Appalachia based on how it compares to national values for indicators every year. Prior to 2012, the ARC used poverty rate estimates from the 2000 Census. In years prior to 2007, the ARC used a different index to measure economic performance which is no longer published.

Counties ranking in the lowest ten percent of all American counties for these economic indicators are classified as "distressed." Counties in the eleventh through twenty-fifth percentiles are "at-risk," counties from the twenty-sixth through the seventy-fifth percentile are "transitional," and counties from the seventy-sixth to ninetieth percentiles are "competitive." The ARC considers any Appalachian county ranked in the highest ten percent of all counties in the United States to have reached "attainment." Figure 3 shows the breakdown of ARC county economic status classification by percentiles.

Figure 3: ARC County Economic Status Classification System. Source: ARC.

It is important to note that the ARC's county economic status index is published for every fiscal year, ending on September 30, while the underlying indicators are calculated for calendar years. The ARC uses the most recently published data available at the time of their report, which means that the data considered in the ARC's economic status classification index for a given

fiscal year are often from several years earlier. Figure 4 shows the publication date for each indicator used to calculate the ARC's county economic status for a given fiscal year.

Fiscal Year (Oct. 1- Sept. 30)	Three-Year Average Unemployment Rate	Per Capita Market Income	Poverty Rate
2019	2014-2016	2016	2012-2016
2018	2013-2015	2015	2011-2015
2017	2012-2014	2014	2010-2014
2016	2011-2013	2013	2009-2013
2015	2010-2012	2012	2008-2012
2014	2009-2011	2011	2007-2011
2013	2008-2010	2010	2006-2010
2012	2007-2009	2009	2005-2009
2011	2006-2008	2008	2000
2010	2005-2007	2007	2000
2009	2004-2006	2006	2000
2008	2003-2005	2005	2000
2007	2002-2004	2004	2000

Figure 4: Data vintage for each county economic status classification fiscal year. Source: ARC.

This study seeks to describe trends in county economic status and its underlying economic indicators from 2007 to 2019 to understand the role of Appalachian Development Highway System spending on post-recession resiliency in the Appalachian Region. First, we identify trends in each of the three economic indicators by plotting the mean and median of the raw indicator scores as well as the ratio of Appalachian indicators to the national average for each indicator over the 13-year period. Next, we compare the distribution of the data for each

indicator in Appalachia as well as the ratio with national indicators in 2007, 2013, and 2019. Comparing both the raw indictor values and the ratio of the Appalachian and national averages allows us to identify trends in the actual levels of unemployment, income, and poverty as well as how Appalachian counties perform relative to the national economy.

County economic status and each associated economic indicator for the period will also be mapped using ArcGIS Pro, a GIS software program. These data are obtained from the ARC's "County Economic Status and Number of Distressed Areas in Appalachia" reports for 2012-2019 and from the ARC's online Data Reports retrieval tool for 2007-2012. The economic indicator data in tabular form are then joined to county boundaries for the Appalachian Region by a common Federal Information Processing Standard (FIPS) field, which is a unique identifier code established for each county in the United States by the Department of Commerce.

Next, we will identify clusters of counties with economic indicator values significantly different from the spatial distribution of economic indicators within the region using Anselin Local Moran's *I* statistic of spatial association given in Figure 5. This statistic will find clusters where adjacent counties share a value for each economic indicator that is significantly higher (high-high) or lower (low-low) than the average for that indicator for the region. It will also identify outliers where the indicator value for a given county is significantly different from adjacent counties (high-low or low-high) within a specified confidence interval. This measure is useful for identifying counties that are performing better or worse than neighboring counties in the region on economic indicators. The counties identified as either outliers or belonging clusters will then be examined further for their relationship the ADHS.

The Local Moran's I statistic of spatial association is given as:

$$I_i = \frac{x_i - \bar{X}}{S_i^2} \sum_{j=1, j \neq i}^{n} w_{i,j}(x_j - \bar{X}) \quad (1)$$

where x_i is an attribute for feature i, $\bar{X}$ is the mean of the corresponding attribute, $w_{i,j}$ is the spatial weight between feature i and j, and:

$$S_i^2 = \frac{\sum_{j=1, j \neq i}^{n} (x_j - \bar{X})^2}{n - 1} \quad (2)$$

with n equating to the total number of features.

The z_{I_i}-score for the statistics are computed as:

$$z_{I_i} = \frac{I_i - \mathrm{E}[I_i]}{\sqrt{\mathrm{V}[I_i]}} \quad (3)$$

where:

$$\mathrm{E}[I_i] = -\frac{\sum_{j=1, j \neq i}^{n} w_{ij}}{n - 1} \quad (4)$$

$$\mathrm{V}[I_i] = \mathrm{E}[I_i^2] - \mathrm{E}[I_i]^2 \quad (5)$$

Figure 5: Anselin Local Moran's I. Source: Esri.

In order to determine which counties had existing ADHS highways and ADHS highways under construction for each county will be calculated by digitizing maps of the ADHS published by the ARC for each fiscal year. Digitizing is a process by which an image is assigned a spatial reference and then its features are manually recreated in a digital format. The product of digitization is a vector dataset with lines representing ADHS roads attributed with their real-world length. ADHS roads falling within the boundaries of each county can be isolated using a "select by location" function to obtain a count of ADHS miles in each respective county. This will allow us to determine which counties in Appalachia were part of the ADHS system, and which counties had ongoing ADHS construction during each year of the study. The location of the ADHS roads relative to clusters and outliers for each economic indicator will be examined.

Chapter 4: Trends in Economic Indicators Over Time

To understand how county economic status was affected by the Great Recession, we observed changes in the measures of central tendency and distribution of three economic indicators: three-year average unemployment rate, per capita market income, and five-year poverty rate estimates. Each of these indicators was examined for fiscal years 2007, 2013, and 2019. Note that data vintages for each of these fiscal years are reported in Figure 4. We find that median unemployment rates increased during the recession but returned to their pre-recession levels by FY 2019; however, the share of counties with unemployment rates greater than two standard deviations above the mean more than doubled from FY 2013 to FY 2019. We also find that the median per capita market income in Appalachia as a percentage of the median per capita market income for the nation decreased from 63% in FY 2007 to 58% in FY 2019. The gap between the lowest-earning and highest-earning counties in Appalachia nearly doubled over the study period. Finally, we find that the median poverty rate in Appalachia is higher than the median poverty rate for the nation over the entire study period. The highest poverty rates in Appalachia decreased from 367% to 281% of the national average from FY 2007 to FY 2019.

Trends in Three-Year Average Unemployment Rate over Time

The three-year average unemployment rates are a measure of the general level of unemployment over a three-year period calculated for the annual Bureau of Labor Statistics' Local Area Unemployment Statistics (LAUS) report. The unemployment data the ARC used to calculate its county economic status index for FY 2007 was from 2002 – 2004. Note the lag between the data vintage and the ARC's index. Over the study period, we find that the average unemployment rate in Appalachia is consistently higher than the national average. The unemployment rate peaks in FY 2013, when the ARC data reflects the 2008 – 2010 LAUS

report, and declines in the post-recession era. Interestingly, as the mean unemployment rate increases from FY 2008 – FY 2014, the mean Appalachian unemployment rate decreases relative to the national mean. While the unemployment rate decreases from FY 2014 – FY 2019, Appalachian unemployment is increasing relative to national unemployment. This suggests that Appalachian counties are recovering jobs at a slower pace than the rest of the nation during this period of economic expansion.

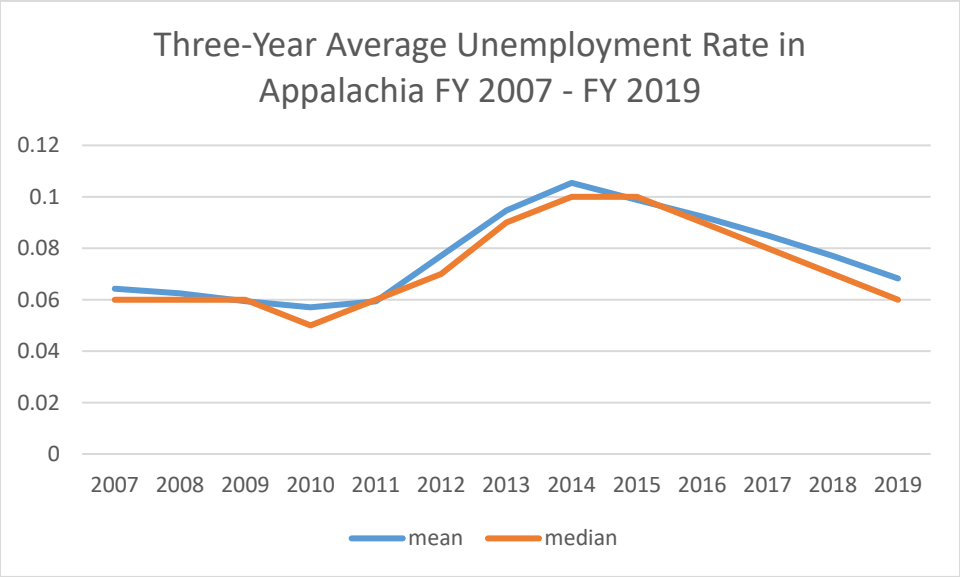

Figure 6: Three-Year Average Unemployment Rate in Appalachia FY 2007 – FY 2019. Generated by author using data from the ARC's County Economic Status Reports and online data retrieval tool.

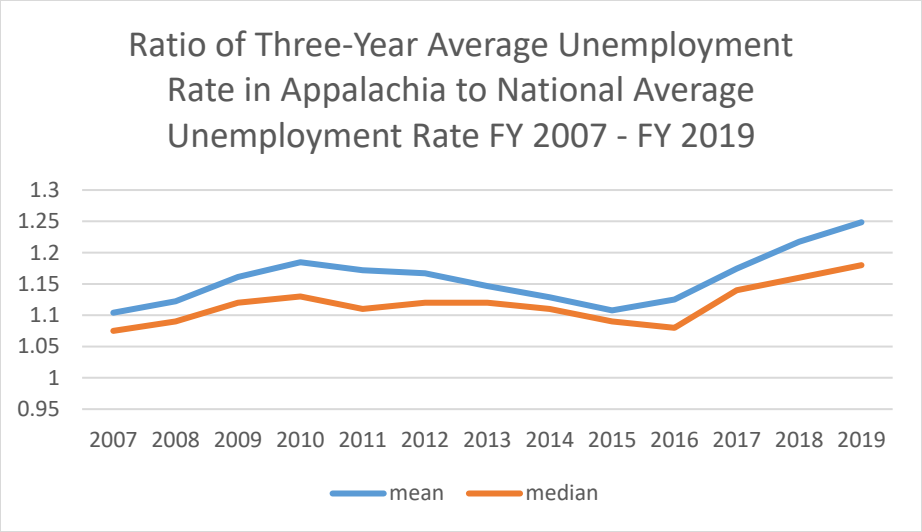

Figure 7: Ratio of the Three-Year Average Unemployment Rate in Appalachia to the National Average Three-Year Average Unemployment Rate FY 2007 – FY 2019. Generated by author using data from the ARC's County Economic Status Reports and online data retrieval tool.

The three-year average unemployment rates for the years observed were not distributed normally. They tended to skew high, with several counties with three-year average unemployment rates more than two standard deviations above the mean.

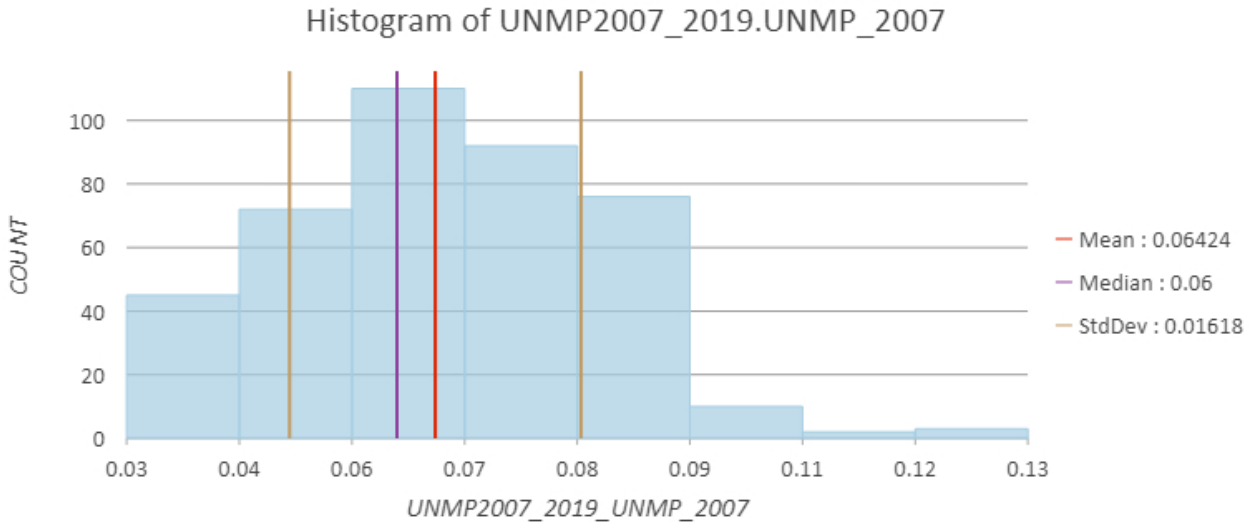

Figure 8: Histogram of the Three-Year Average Unemployment Rate for Appalachia in FY 2007. Generated by author using data from the ARC's online data retrieval tool.

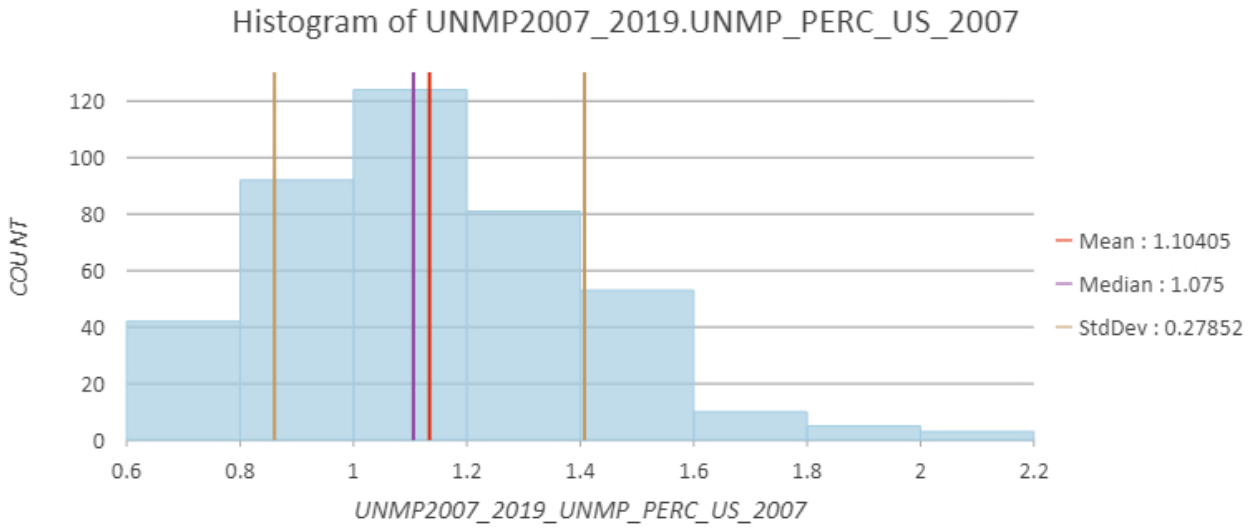

Figure 9: Histogram of Ratio of the Three-Year Average Unemployment Rate in Appalachia to the Average National Three-Year Average Unemployment Rate in FY 2007. Generated by author using data from the ARC's online data retrieval tool.

Note that the median three-year average unemployment rate for Appalachia was 6% in FY 2007, and the three-year average unemployment rate for the median county in Appalachia was 1.08 times the national average. The unemployment rates range from 3% to 13%. While most counties in Appalachia experienced unemployment rates similar to the rest of the nation, a few counties had significantly higher unemployment, up to 2.2 times the national average. Fifteen counties, or 3.66% of counties observed for FY 2007 were more than two standard deviations above the mean.

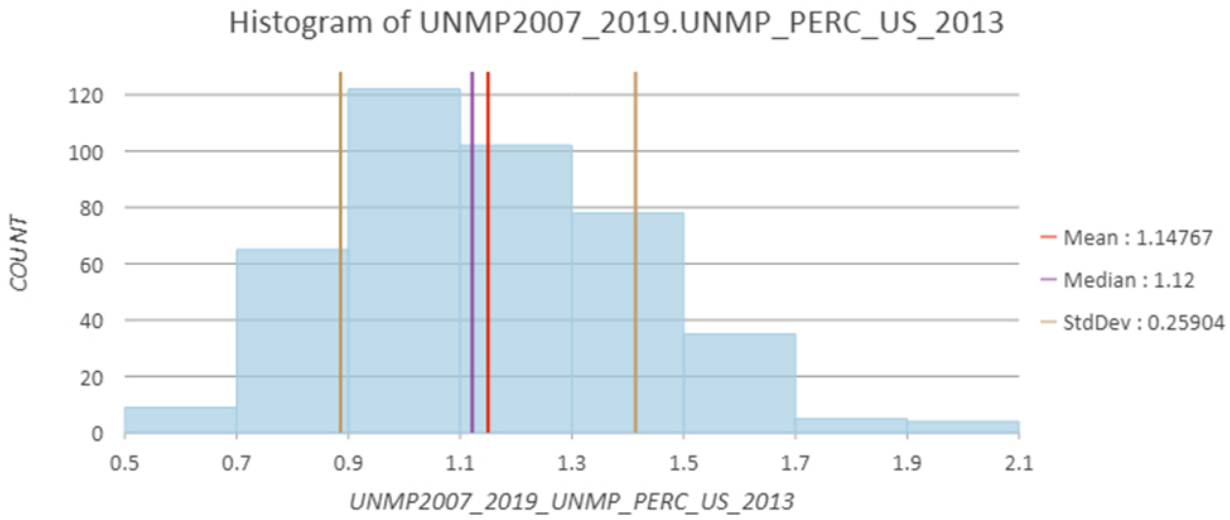

Figure 10: Histogram of the Three-Year Average Unemployment Rate for Appalachia in FY 2013. Generated by author using data from the ARC's County Economic Status Reports.

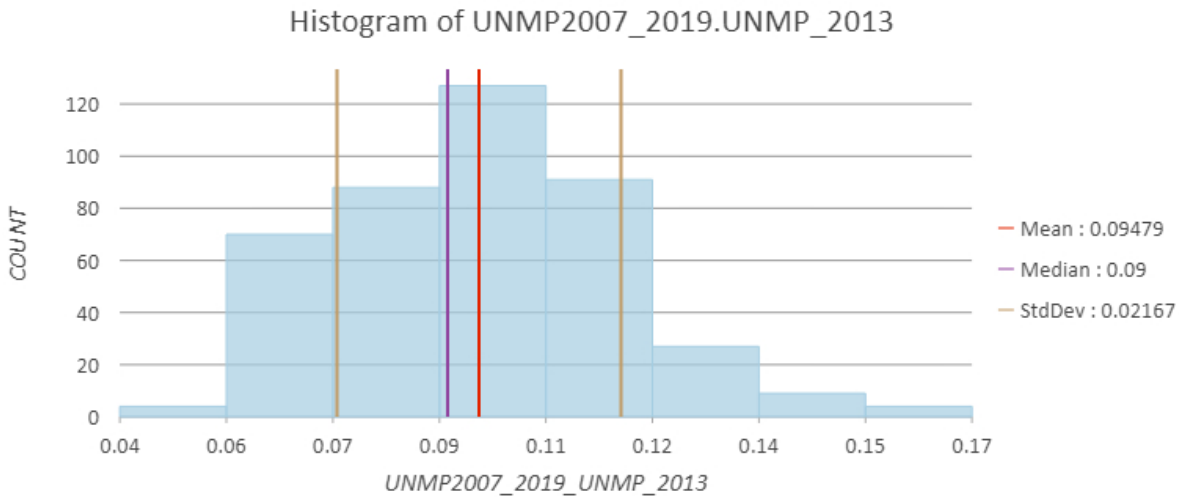

Figure 11: Histogram of Ratio of the Three-Year Average Unemployment Rate in Appalachia to the Average National Three-Year Average Unemployment Rate in FY 2013. Generated by author using data from the ARC's County Economic Status Reports.

Fiscal year 2013 was the first year that ARC county economic status reflected data from the recession period, with three-year average unemployment rates derived from the LAUS report for 2008 – 2010. The median three-year average unemployment rate for the Appalachian region was 9%, which is only 1.18 times the national. The share of counties with an unemployment rate

more than two standard deviations above the mean decreased from 3.66% in FY 2007 to 2.39% in FY 2013.

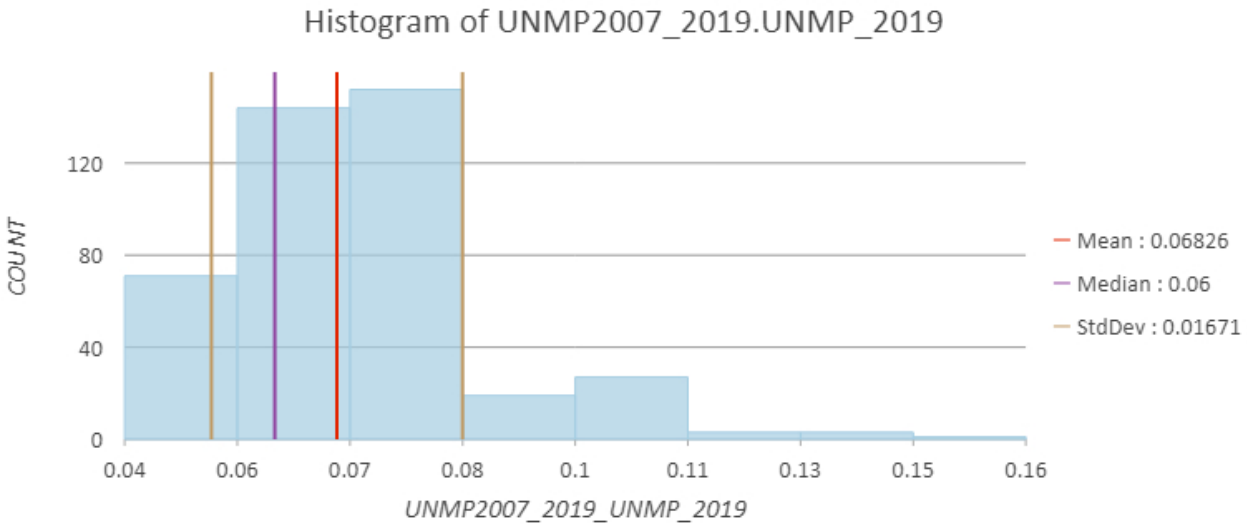

Figure 12: Histogram of the Three-Year Average Unemployment Rate for Appalachia in FY 2019. Generated by author using data from the ARC's County Economic Status Reports.

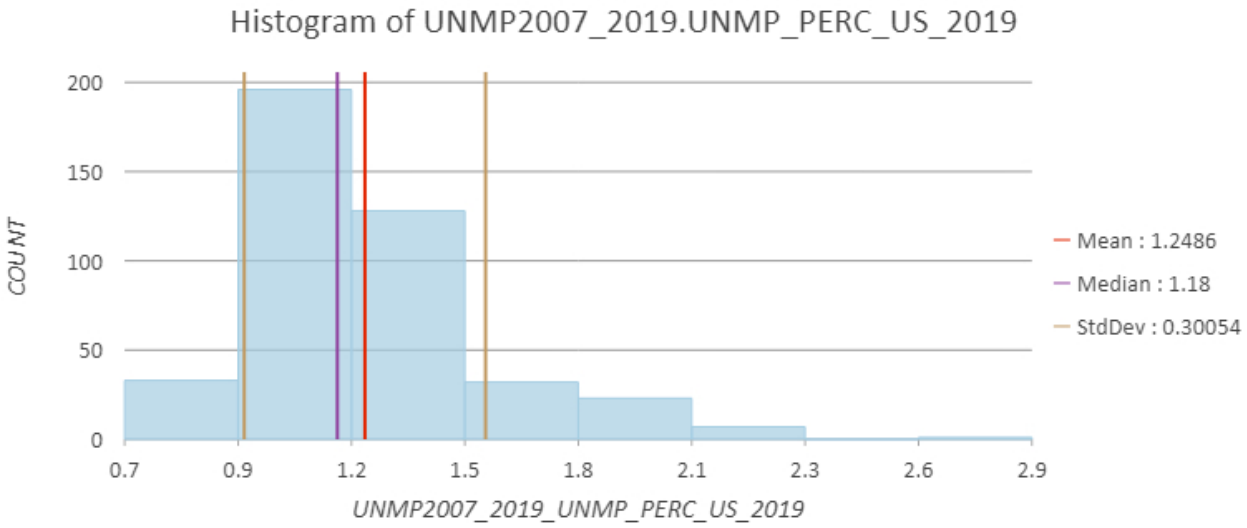

Figure 13: Histogram of Ratio of the Three-Year Average Unemployment Rate in Appalachia to the Average National Three-Year Average Unemployment Rate in FY 2019. Generated by author using data from the ARC's County Economic Status Reports.

By FY 2019, the median three-year average unemployment rate returned to its pre-recession value of 6%, which is 1.2 times the national median for 2019. The distribution of three-year average unemployment rates is notably different from 2013. The maximum three-year average unemployment rate in FY 2019 was 16%, only one percentage point lower than during the recession, and the share of counties more than two standard deviations above the mean increased to 6.21%. This suggests that the counties experiencing the highest unemployment rates are recovering more slowly than the rest of the nation.

Trends in Per Capita Market Income Over Time

Appalachian counties have consistently exhibited lower incomes than the rest of the nation since the creation of the ARC by a number of different measures. The ARC uses the per capita market income indicator from the Bureau of Economic Analysis's Local Area Personal Income report. Per capita market income is based on quarterly unpublished estimated from the Census Bureau (BEA 2018). We find that incomes have been rising consistently over the study period, except for a small dip from FY 2012 – FY 2014, which reflects data from 2009 – 2011 during the recession. While incomes are increasing in Appalachia, the data reflect a downward trend in Appalachian incomes relative to national incomes.

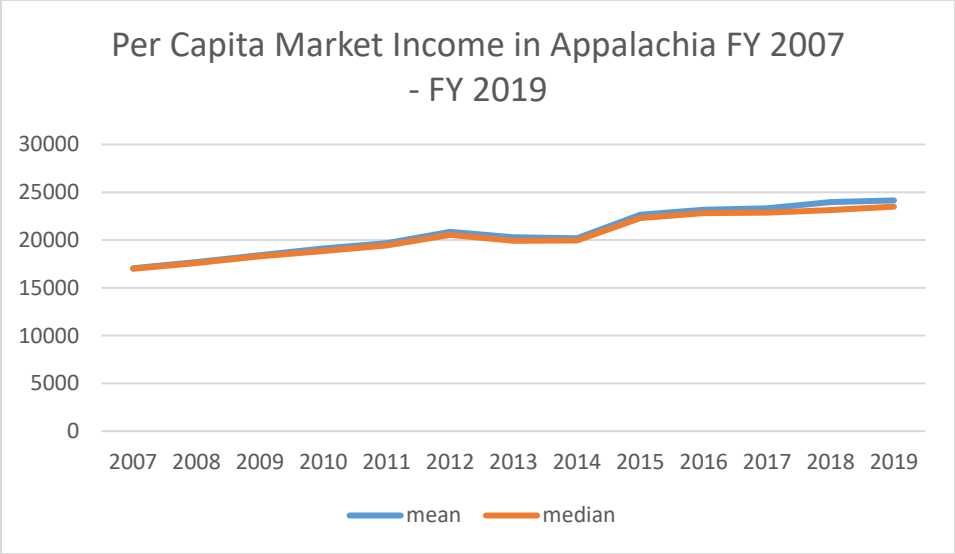

Figure 14: Mean and Median Per Capita Market Income in Appalachian Counties FY 2007 – FY 2019. Generated by author using data from the ARC's County Economic Status Reports and online data retrieval tool.

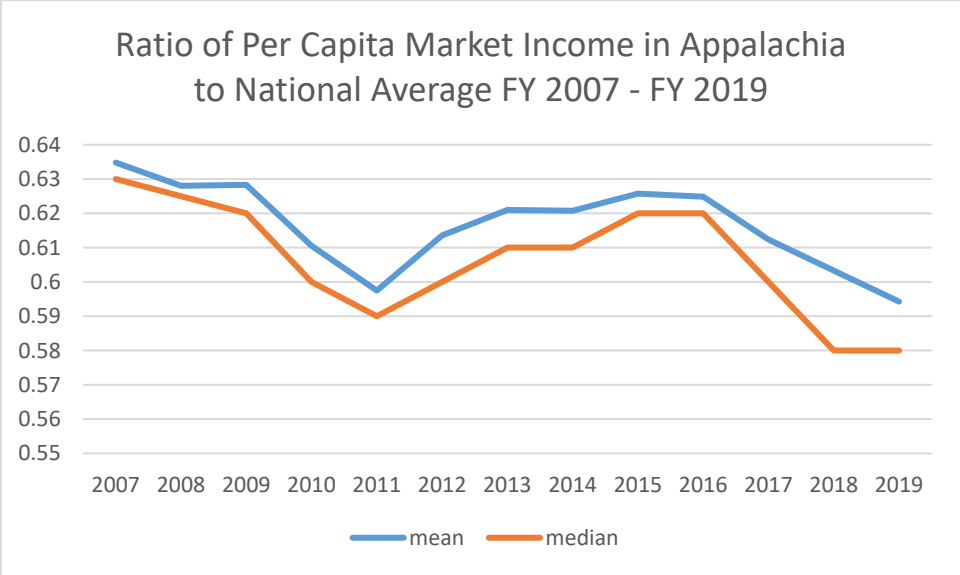

Figure 15: Ratio of Per Capita Market Income in Appalachia to the National Average Per Capita Market Income FY 2007 – FY 2019. Generated by author using data from the ARC's County Economic Status Reports and online data retrieval tool.

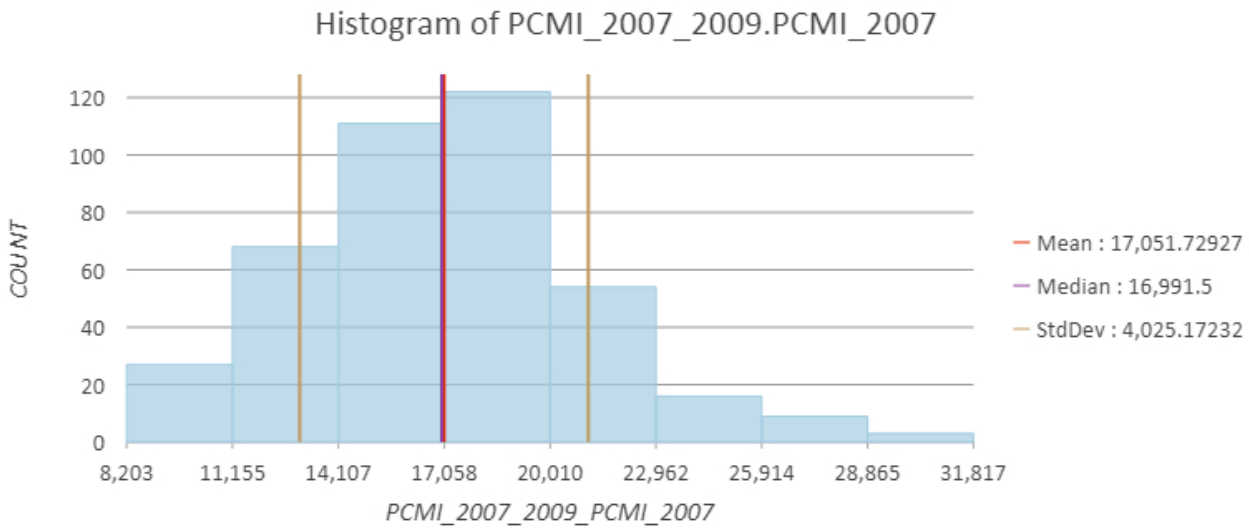

Figure 16: Histogram of Per Capita Market Income in Appalachian Counties for FY 2007. Generated by author using data from the ARC's online data retrieval tool.

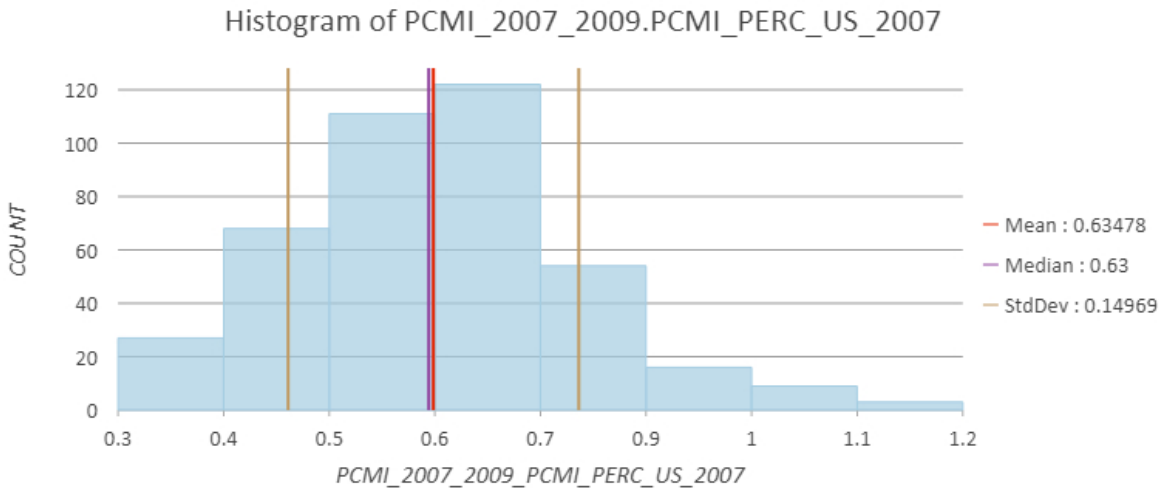

Figure 17: Histogram of Per Capita Market Income in Appalachia as a Ratio of the National Average Per Capita Market Income for FY 2007. Generated by author using data from the ARC's online data retrieval tool.

In FY 2007, the ARC's county economic status indicator drew per capita market income from the Bureau of Economic Analysis's Local Area Personal Income report for 2004. The median individual market income for the region was $16,992. This was only 63% of the national

median per capita market income for that year. The highest-earning county in Appalachia only attained a per capita market income 118% of the national average, while workers in the lowest-earning county made 31% of the national average.

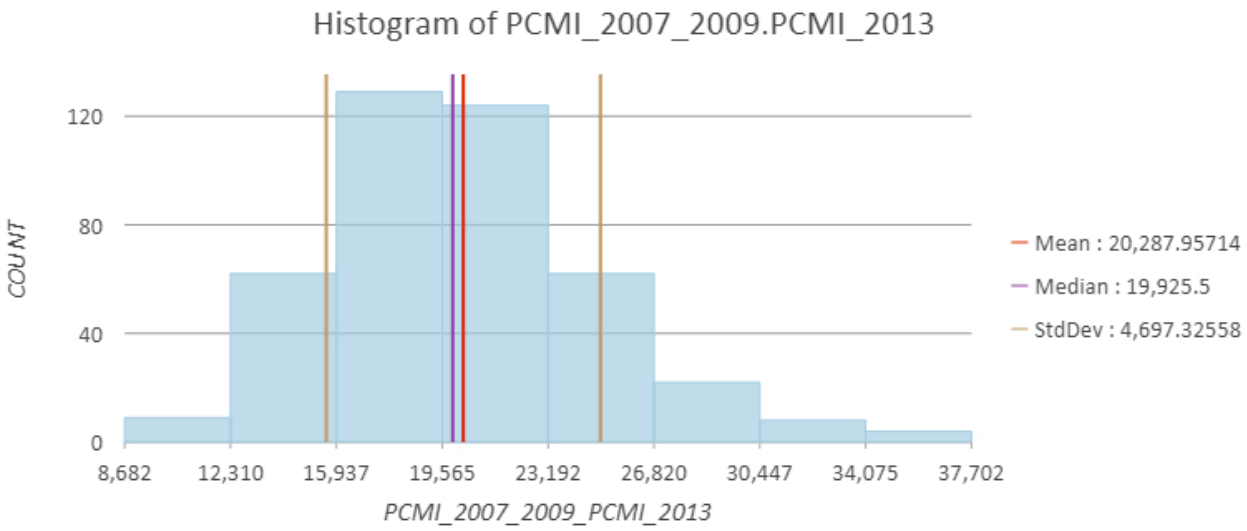

Figure 18: Histogram of Per Capita Market Income in Appalachian Counties for FY 2013. Generated by author using data from the ARC's County Economic Status Reports.

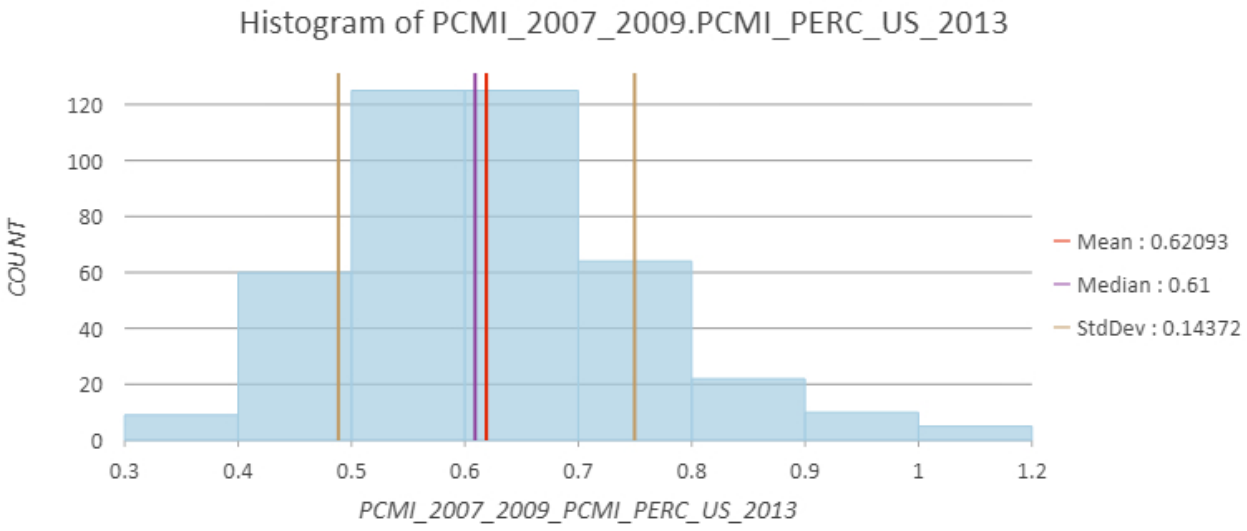

Figure 19: Histogram of Per Capita Market Income in Appalachia as a Ratio of the National Average Per Capita Market Income for FY 2013. Generated by author using data from the ARC's County Economic Status Reports.

By FY 2013, the median per capita market income in Appalachia increased to $19,926, which was 61% of the national median. We used a t-test to determine that the two-percentage point decrease from 63% to 61% of the national median in FY 2007 to FY 2013 was not statistically significant. Note that the lowest-earning counties in Appalachia did not make significant gains from FY 2007 to FY 2013, but the highest-earning counties saw an increase in per capita market income from $31,817 to $37,702.

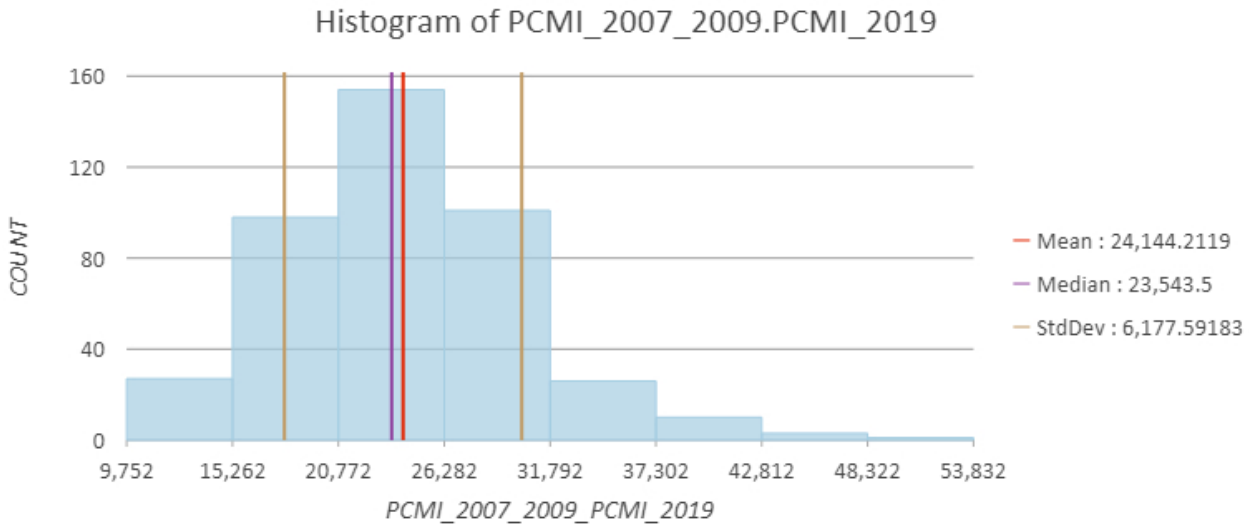

Figure 20: Histogram of Per Capita Market Income in Appalachian Counties for FY 2019. Generated by author using data from the ARC's County Economic Status Reports.

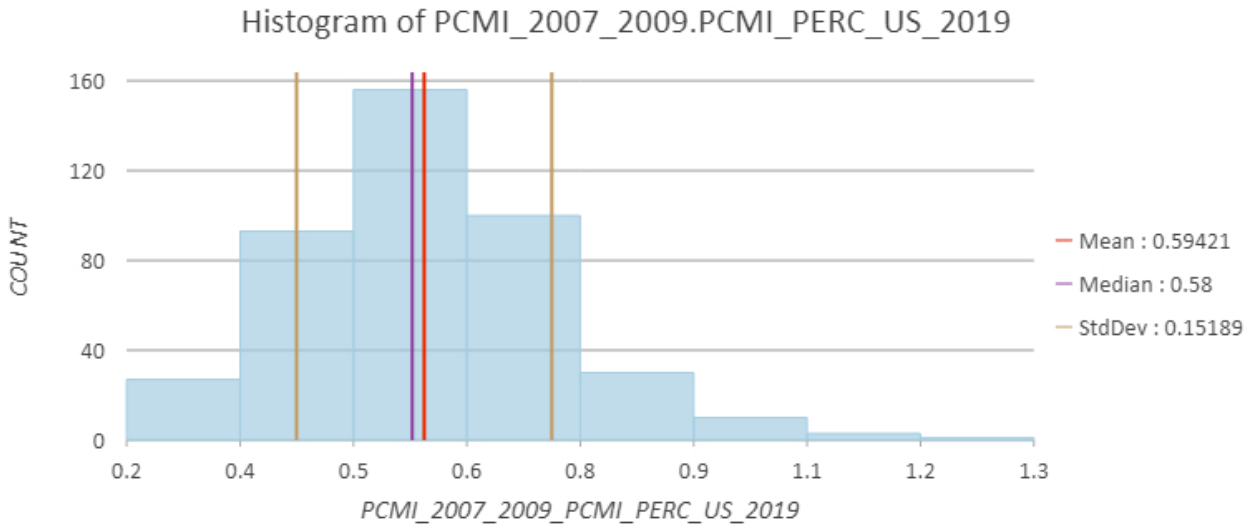

Figure 21: Histogram of Per Capita Market Income in Appalachia as a Ratio of the National Average Per Capita Market Income for FY 2019. Generated by author using data from the ARC's County Economic Status Reports.

By FY 2019, median per capita market income increased to $23,544. The median income for Appalachia was 58% of the national median, down from 63% of the national median in FY 2007. This was a statistically significant difference at p=0.05. The range for per capita market incomes in Appalachia was $23,614 in FY 2007, while in FY 2019 the gap between the lowest- and highest-earning counties in Appalachia was $44,080. This suggests that incomes in Appalachia actually decreased relative to national incomes in the post-recession era, while the discrepancy in incomes across the Appalachian region increased.

Trends in Poverty Rates over Time

The most recent poverty rate estimate available for the ARC's FY 2007 county economic status index was the 2000 census. For poverty rates in FY 2013 and FY 2019, the ARC used the American Community Survey's five-year estimates for 2006 – 2010 and 2012 – 2016, respectively. The trends in poverty rate over the study period are difficult to determine because the ARC used the same 2000 census estimate for poverty rates for Appalachian counties from

FY 2007 – FY 2011, so the jump in the ratio of the average poverty rate in Appalachia to the national average in FY 2012 likely does not reflect reality.

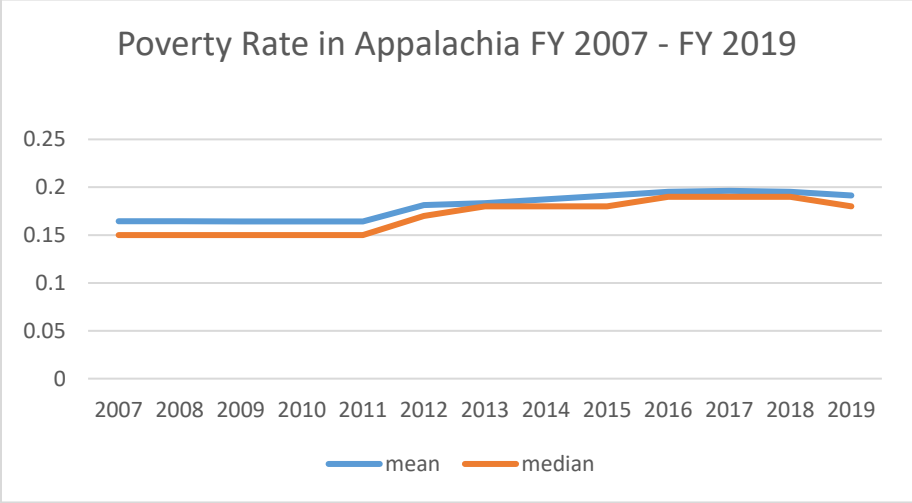

Figure 22: Mean and Median Poverty Rate for Appalachian Counties for FY 2007 – FY 2019. Generated by author using data from the ARC's County Economic Status Reports and online data retrieval tool.

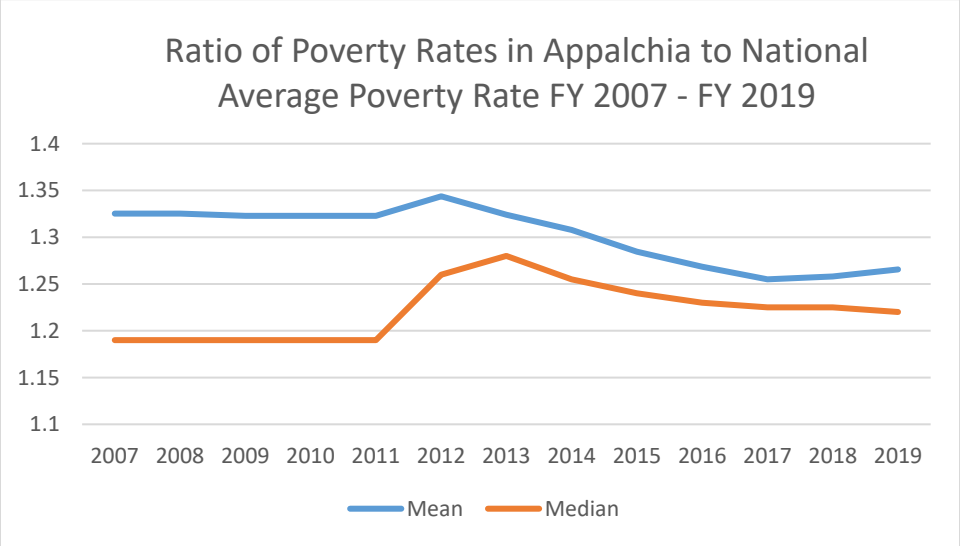

Figure 23: Ratio of Poverty Rates in Appalachia to National Average Poverty Rate FY 2007–FY2019. Generated by author using data from the ARC's County Economic Status reports and online data retrieval tool.

Appalachian poverty rates have declined relative to national poverty rates since FY 2013, while the mean level of poverty in Appalachia has trended slightly upward from 18% in FY 2013 to 19% in FY 2019. Note that the mean and median poverty rates diverge from each other in FY 2019, suggesting that a few counties with high poverty rates are causing the mean to skew upwards relative to the median.

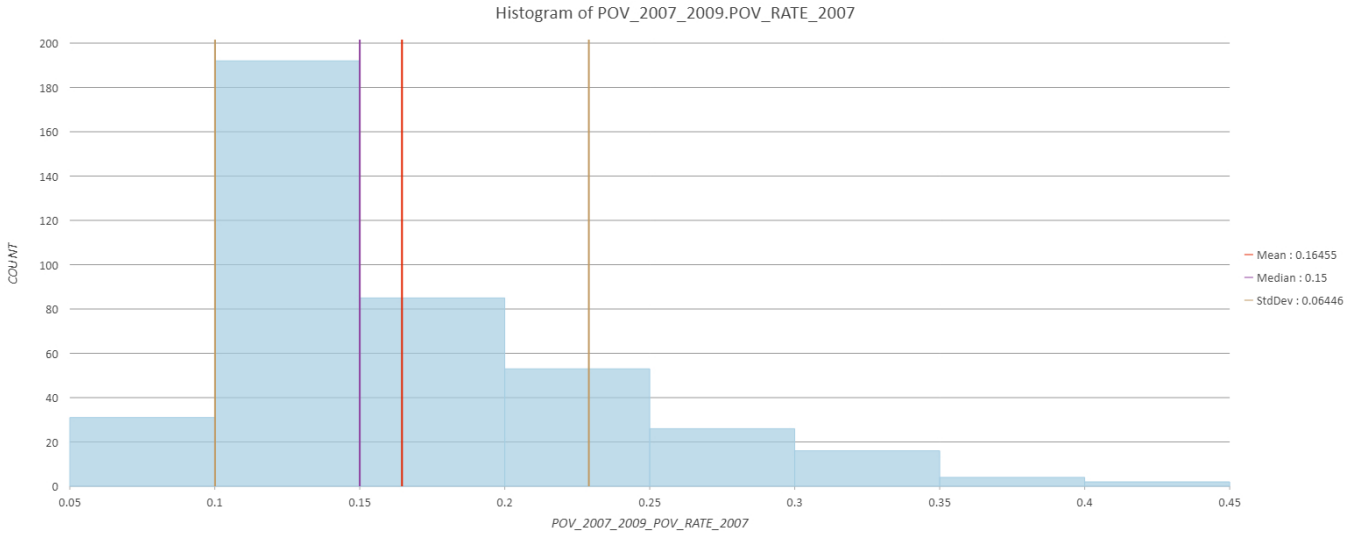

Figure 24: Histogram of Poverty Rate Estimate in Appalachian Counties for FY 2007. Generated by author using data from the ARC's online data retrieval tool.

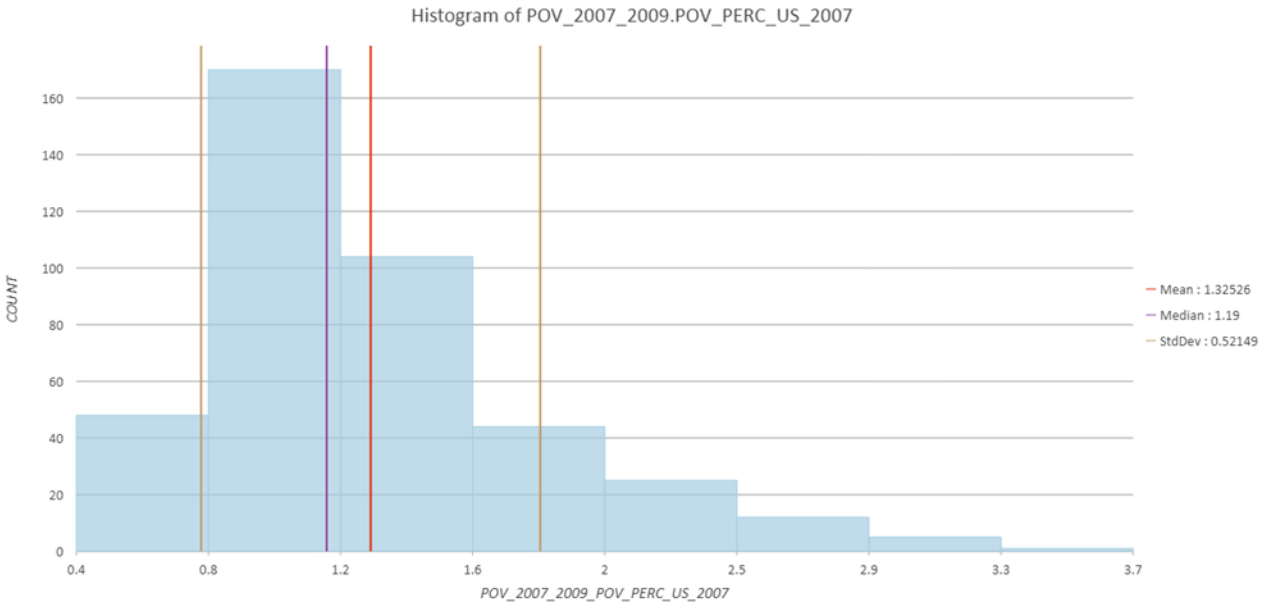

Figure 25: Histogram of Poverty Rate Estimate in Appalachia as a Ratio of the National Average Five-Year Poverty Rate Estimate for FY 2007. Generated by author using data from the ARC's County Economic Status online data retrieval tool.

The median poverty rate in Appalachia for FY 2007 was 15%, which was 1.19 times the national median. Poverty rates in Appalachian counties were as high as 3.7 times the national average, with 5.4% of counties observed more than two standard deviations above the mean. The poverty rates within Appalachia ranged from 5% to 45%, and the highest poverty rate in Appalachia was 367% of the national average.

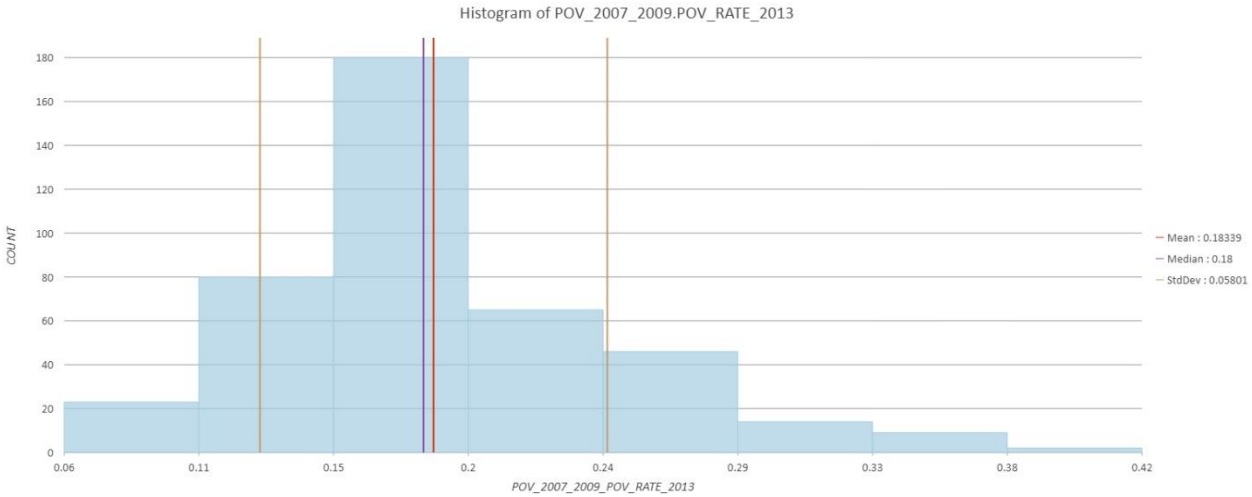

Figure 26: Histogram of Five-Year Poverty Rate Estimate in Appalachia for FY 2013. Generated by author using data from the ARC's County Economic Status Reports.

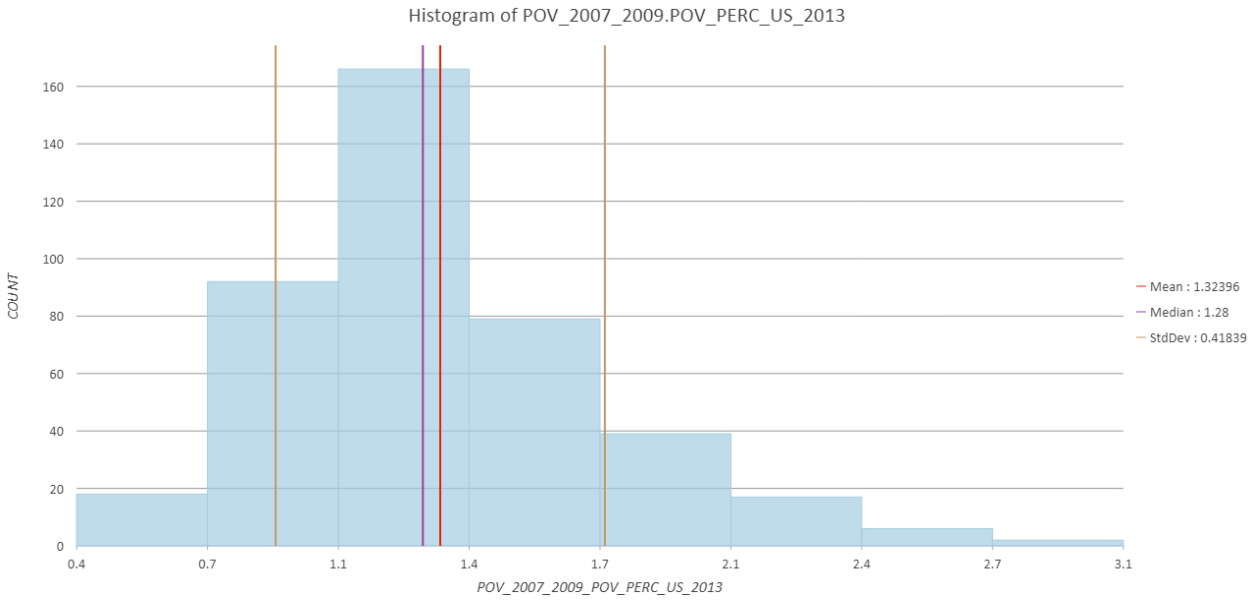

Figure 27: Histogram of Five-Year Poverty Rate Estimates in Appalachia as a Ratio of the National Average Five-Year Poverty Rate Estimate for FY 2013. Generated by author using data from the ARC's County Economic Status Reports.

The median unemployment rate for Appalachian counties increased to 18% in FY 2013. The median county in Appalachia was estimated to have a poverty rate 1.28 times the national median. Poverty rates ranged from 6% to 42%, which is from 40% to 306% of the national

average. The share of Appalachian counties with poverty rates more than two standard deviations above the national mean was 4.3%, down from 5.4% in FY 2007.

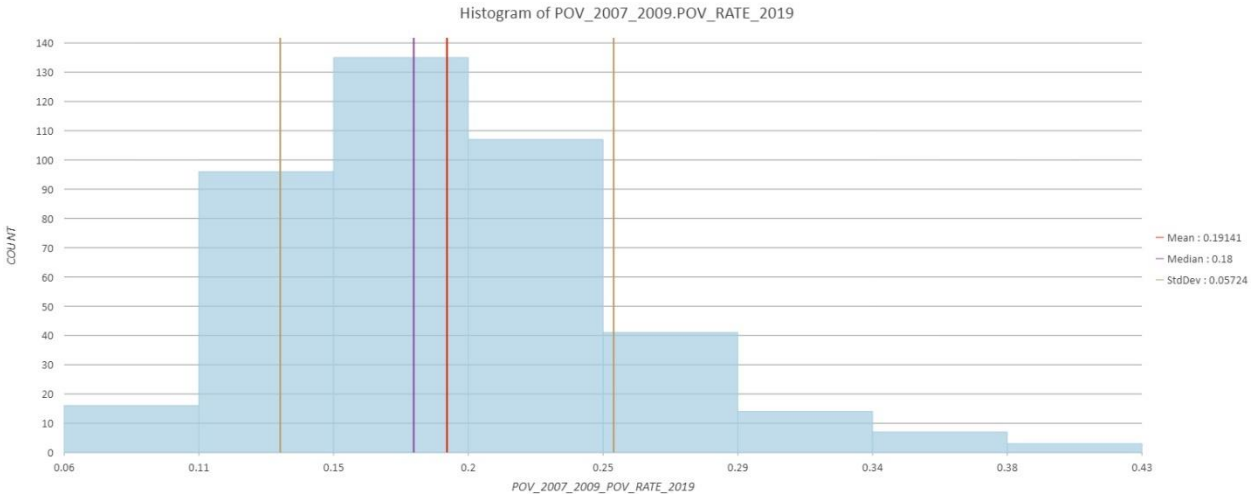

Figure 28: Histogram of Five-Year Poverty Rate Estimate in Appalachia for FY 2019. Generated by author using data from the ARC's County Economic Status Reports.

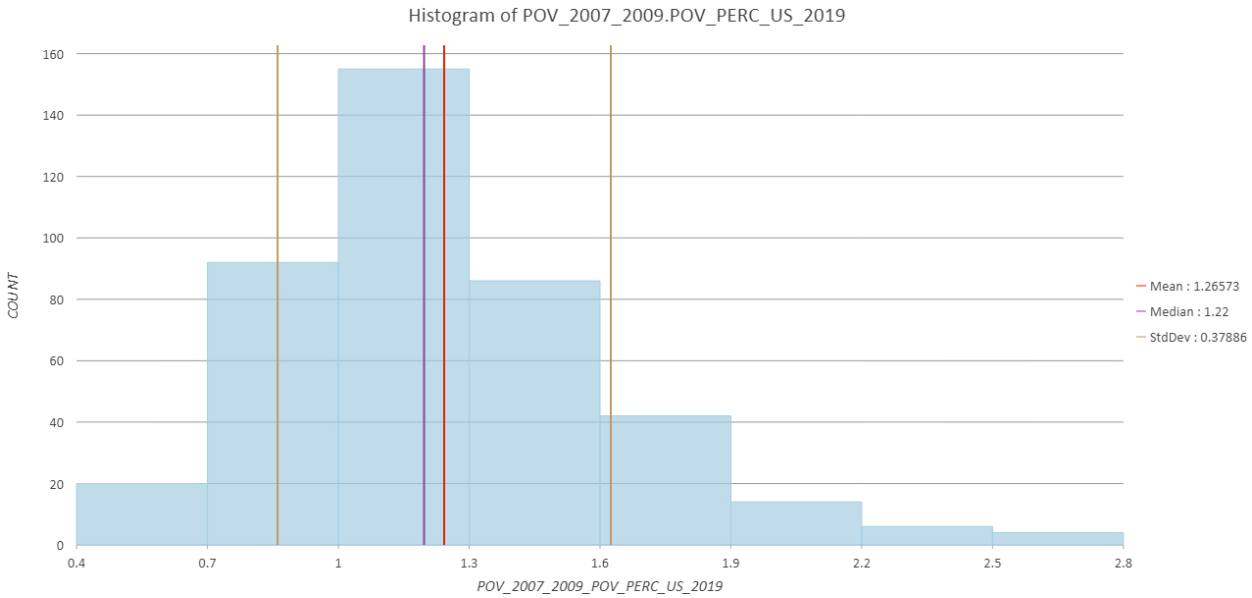

Figure 29: Histogram of Five-Year Poverty Rate Estimates in Appalachia as a Ratio of the National Average Five-Year Poverty Rate Estimate for FY 2019. Generated by author using data from the ARC's County Economic Status Reports.

The median poverty rate in Appalachia in FY 2019 was 18% with no change from FY 2013. Poverty rate estimates for Appalachian counties ranged from 6% to 43%, also similar to FY 2013. The median Appalachian county experienced a poverty rate 1.22 times the national median, while the maximum poverty rate in Appalachia was 281% of the national average. The share of Appalachian counties with poverty rates more than two standard deviations above the mean was 4.8%, which was up from 4.3% in FY 2013 but still less than the FY 2007 share of 5.4%. Overall, poverty rates in Appalachia have increased over the study period, and they remain higher in Appalachia than in the rest of the nation.

Chapter 5: Spatial Trends in Economic Indicators

In order to understand the relationship between location and economic indicators in the Appalachian region, we used Anselin Local Moran's I statistic to identify spatial clusters and outliers for the three-year average unemployment rate, per capita market income, and five-year poverty rate estimates. Each of these indicators was examined for fiscal years 2007, 2013, and 2019. Anselin Local Moran's I statistic is used to demonstrate where counties with statistically significant differences from the mean for an indicator are clustered and where there are spatial outliers. County clusters with similarly high values for an indicator are displayed in light purple. Counties with high indicator values adjacent to counties with low indicator values are dark purple. Clusters of counties with similarly low indicator values are light green, while counties with low-values adjacent to high-value clusters are dark green. All clusters and outliers reported are significant at the $p = 0.05$ level. Counties that do not exhibit a statistically significant difference from the mean are white.

After isolating clusters and outliers, we isolated counties which did have ADHS roads present and those that did not. We then calculated the mean three-year average unemployment rate, per capita market income, and five-year poverty rate estimate for counties with versus without ADHS roads for 2007, 2013, and 2019. After calculating the test-statistic for each indicator and each year, we did not find any statistically significant differences between the mean indicator values for counties with ADHS roads.

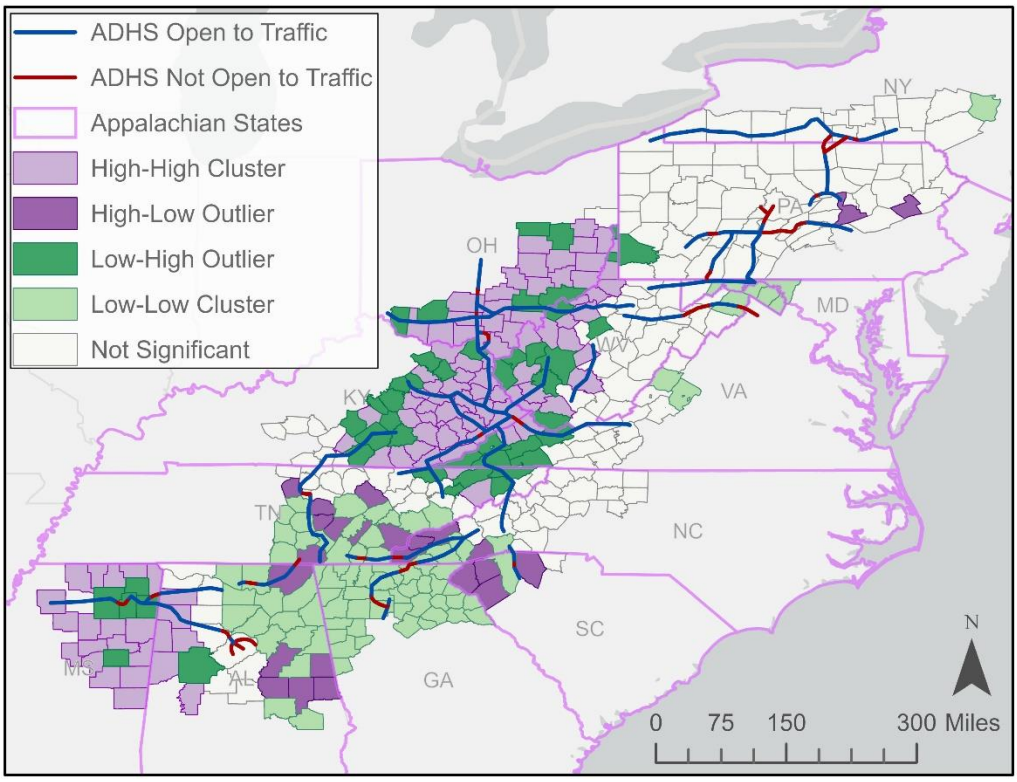

Figure 30: Cluster and Outlier Analysis of Three-Year Average Unemployment Rate in Appalachia and the ADHS in FY 2007. Generated by the author using data from the ARC's online data retrieval tool.

Spatial Trends in Three-Year Average Unemployment Rates

Figure 30 shows the cluster and outlier analysis for the three-year average unemployment rate for the Appalachian region in FY 2007. There is a cluster of counties with high unemployment rates from 7% to 10% in Ohio, Kentucky, and West Virginia, and another cluster with unemployment rates from 7% to 12% in Mississippi and western Alabama. Note outliers with low unemployment rates in eastern Tennessee and the southwestern point of Virginia, in central Kentucky, and around Charleston, West Virginia all ranging from 5%-6% unemployment. There are two clusters of low unemployment rates: one in eastern Alabama, Georgia, Tennessee, and North Carolina and another in western Maryland and northern Virginia.

The unemployment rates for the low clusters range from 3% – 6% and 4% – 6%, respectively. The high unemployment outliers scattered across the low cluster in the South range from 7% – 8%.

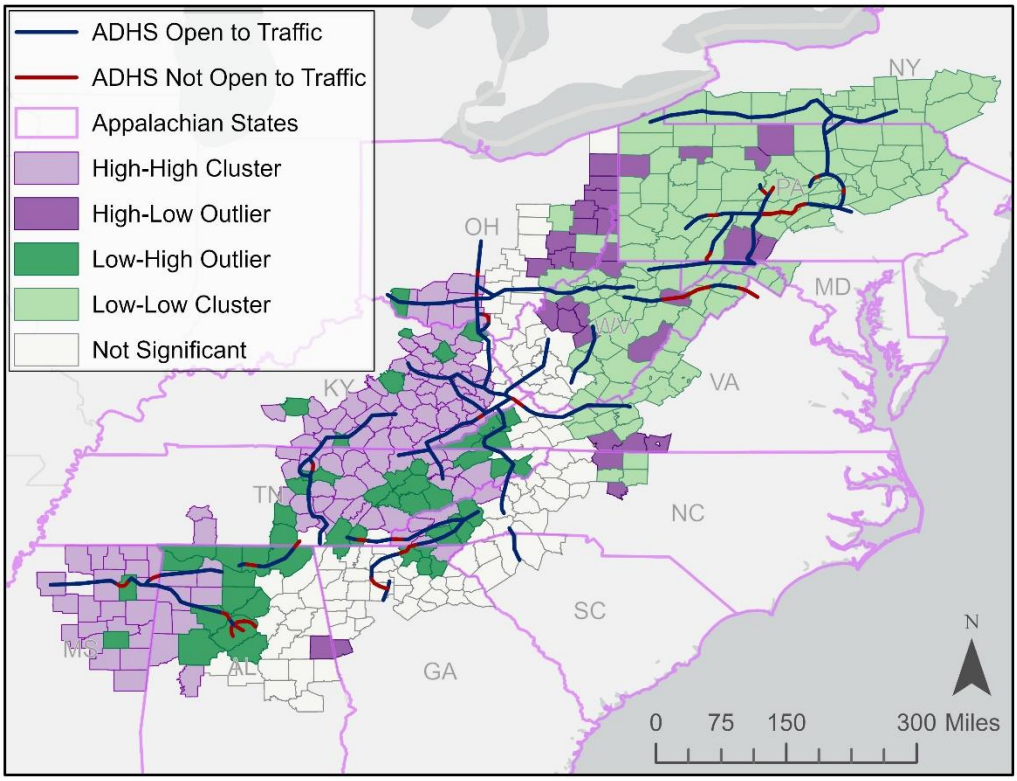

Figure 31: Cluster and Outlier Analysis of Three-Year Average Unemployment Rate in Appalachia and the ADHS in FY 2013. Generated by the author using data from the ARC's County Economic Status Report.

In FY 2013, there was a cluster of high unemployment rates in Ohio, Kentucky, central Tennessee, and North Carolina ranging from 10% – 16% and another cluster ranging from 10% – 17% in Mississippi and Alabama. Note the low unemployment outliers in central Alabama around Birmingham and in eastern Tennessee, both ranging from 7% – 9%. New York, Pennsylvania, Maryland, Virginia, and the panhandle of West Virginia exhibited lower than average unemployment, ranging from 6% – 9%. Note high unemployment outliers in central

West Virginia, 10% – 11% and eastern Ohio, 10% – 13%. While the level of unemployment was higher across the region in FY 2013, areas in Tennessee and Georgia that were part of a low unemployment cluster in FY 2007 exhibited higher than average unemployment in FY 2013, suggesting that this area experienced more job loss relative to the rest of the region during the recession. The Northeast and Mid-Atlantic seemed to fare better with less job losses relative to the South.

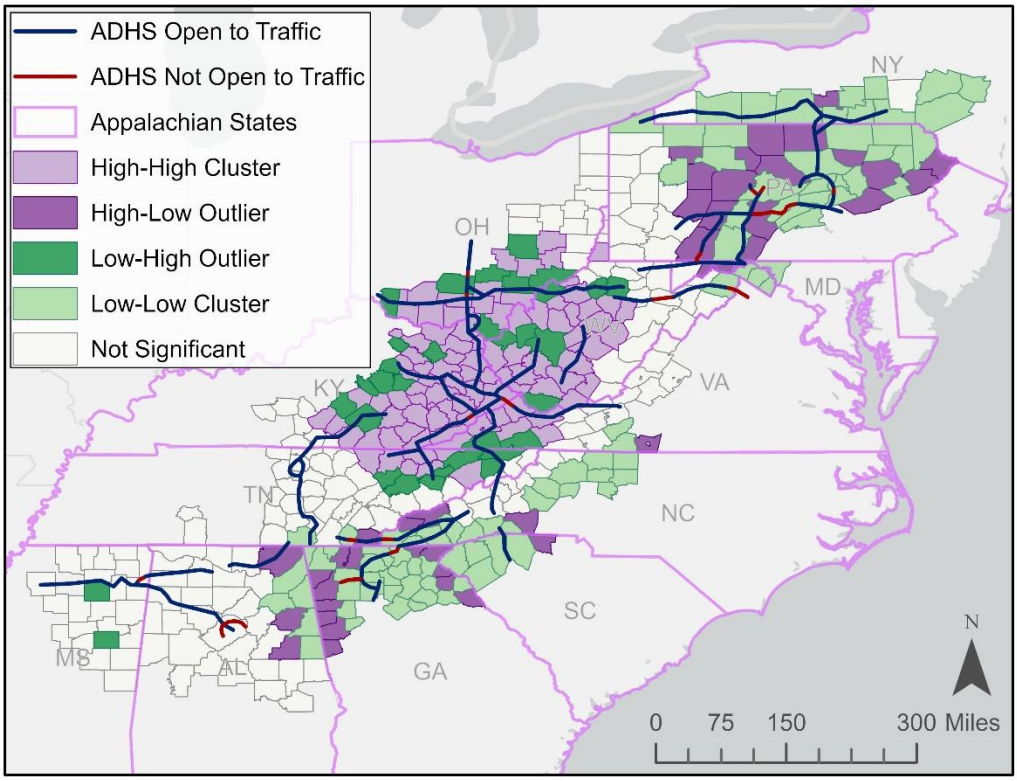

Figure 32: Cluster and Outlier Analysis of Three-Year Average Unemployment Rate in Appalachia and the ADHS in FY 2019. Generated by the author using data from the ARC's County Economic Status Report.

Mississippi and Alabama recovered enough jobs to transition from a high-unemployment cluster in FY 2013 to not significantly different from the region mean in FY 2019. A cluster of low unemployment emerged across Georgia, South Carolina, and North Carolina ranging from

4% – 6%. The high unemployment outliers within this cluster range from 7% – 11%. The low-unemployment cluster in the Northeast spanned New York, Pennsylvania, and Maryland with rates 4% – 6%. The high outliers in central Pennsylvania range from 7% – 8%. Ohio, Kentucky, Virginia, and West Virginia exhibited higher than average unemployment rates from 7% – 13%. The low outliers in this cluster are around Charleston and Parkersburg, West Virginia, Athens, Ohio, and Knoxville, Tennessee, with unemployment rates from 5% – 6%.

Overall, regional unemployment levels decreased from FY 2013 to FY 2019. The areas with the highest unemployment rates remained centralized around Kentucky, Tennessee, and West Virginia. The areas with the lowest unemployment rates shifted from Alabama, Georgia, and Tennessee in FY 2007, to the Northeast in FY 2013, and finally to New York, Pennsylvania, North Carolina, South Carolina, and Georgia in FY 2019. This may be because manufacturing jobs in the South at the beginning of the study period were not recovered after the recession, and jobs shifted to the more urban, coastal areas in the post-recession period. There was no statistically significant difference between the mean unemployment rates for counties with ADHS roads versus those without.

Spatial Trends in Per Capita Market Income

The spatial trends in per capita market income resemble the trends in unemployment rates over the study period. Clusters of high unemployment and low income and vice versa tend to coincide in the region. Central Appalachia exhibits a persistent cluster of the lowest per capita market incomes for the region, while New York, Pennsylvania, and Maryland exhibit clusters of high incomes. An increasing share of North Carolina exhibits low incomes over the study period, and a high-income cluster in Alabama, Georgia, and South Carolina in FY 2007 disappears by

FY 2019. There was no statistically significant difference in per capita market income in counties with ADHS roads versus those without ADHS roads.

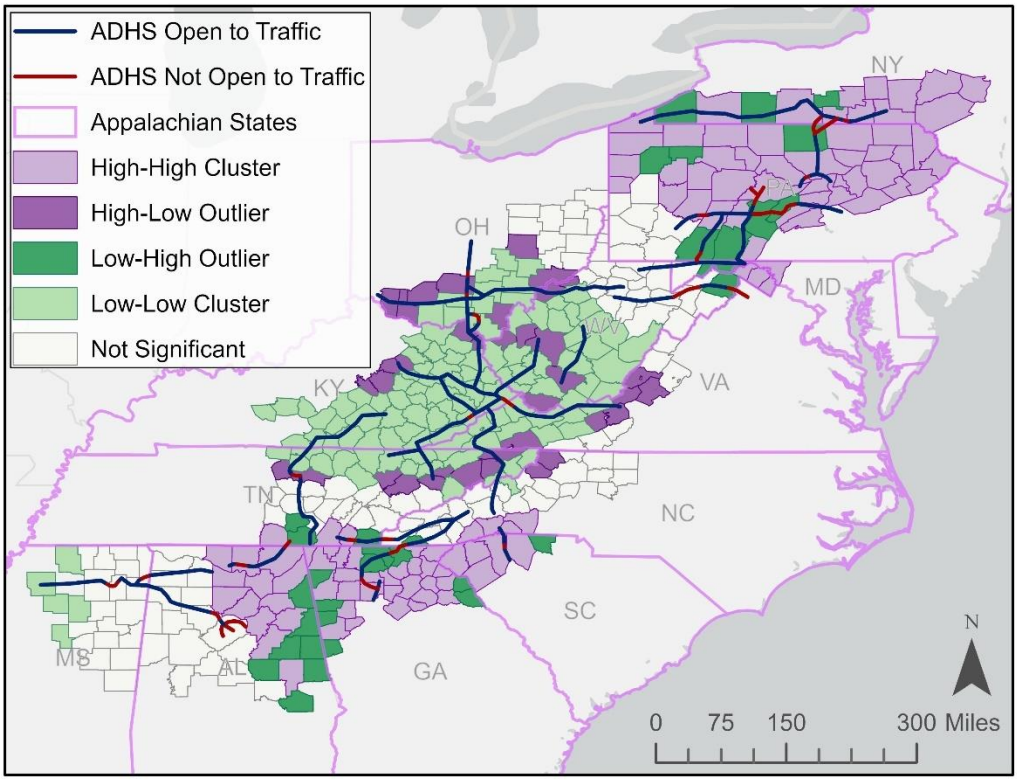

Figure 33: Cluster and Outlier Analysis of Per Capita Market Income in Appalachia and the ADHS in FY 2007. Generated by the author using data from the ARC's online data retrieval tool.

In FY 2007, there were two clusters of low incomes in Mississippi and in central Appalachia, including Ohio, Kentucky, Tennessee, West Virginia, and Virginia. Incomes in the low cluster in Mississippi ranges from $14,016 to $16,628. Incomes in the central cluster range from $8,203 to $16,994. High income outliers within this low cluster range from $17,069 to $26,863. They are centered around cities including Cincinnati, Ohio, Lexington, Kentucky, Knoxville, Tennessee, Charleston and Parkersburg, West Virginia, and Blacksburg and Bristol, Virginia. There is a cluster of high incomes in Alabama, Georgia, and South Carolina ranging from $17,163 to $31,817. The low-income outliers within this cluster range from $12,101 to

$16,971. Another cluster of high incomes in New York, Pennsylvania, and Maryland ranges from $17,148 to $24,771 with low outliers from $14,331 to $16,971.

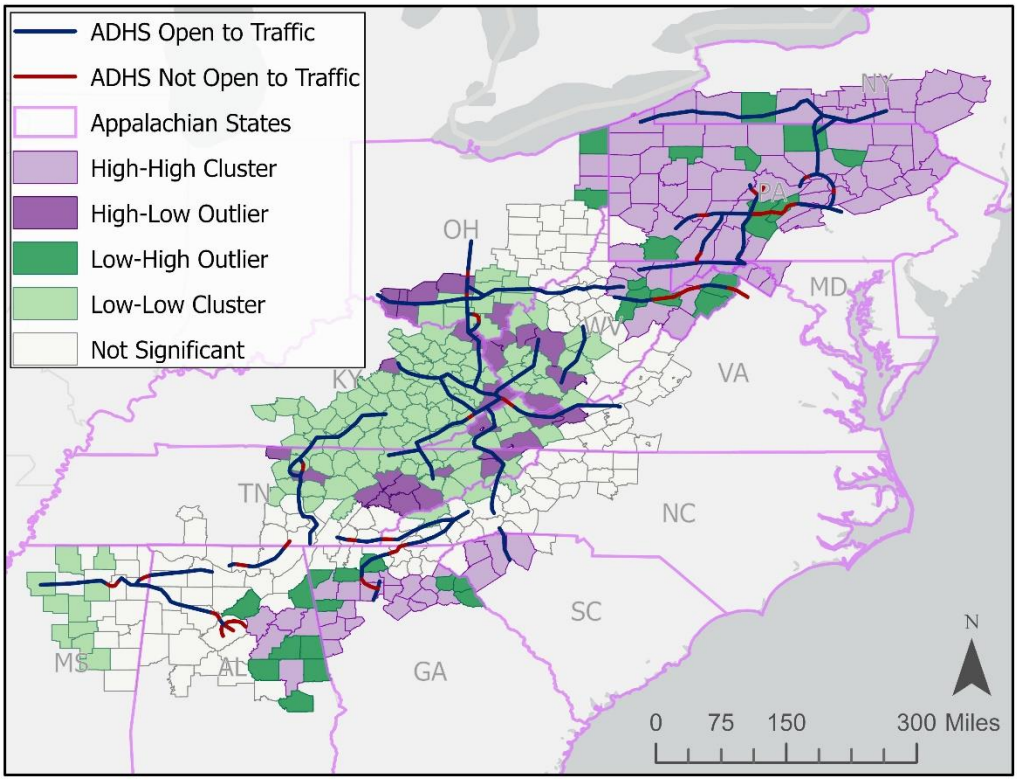

Figure 34: Cluster and Outlier Analysis of Per Capita Market Income in Appalachia and the ADHS in FY 2013. Generated by the author using data from the ARC's County Economic Status Report.

In FY 2013, counties in the low-income cluster in Mississippi exhibited per capita market incomes from $14,090 to $19,127. The low-income cluster in Ohio, Kentucky, Tennessee, West Virginia, Virginia, and North Carolina ranged from $8,682 to $20,055. The high-income outliers within central Appalachia were again centered around urban areas including Cincinnati, Lexington, Knoxville, Charleston, and Bristol. They ranged from $20,414 to $31,863 in per capita market income. Alabama, Georgia, and South Carolina formed a high-income cluster of $20,502 to $37,702 with low income outliers of $14,625 to $20,153. The high-income cluster in

the northeastern states of New York, Pennsylvania, Ohio, Maryland, and northern Virginia encompassed counties with per capita market incomes from $20,362 to $37,640. The low-income outliers in this cluster ranged from $14,796 to $19,924 and were scattered across the less urbanized parts of those states. These counties did not have any metropolitan or micropolitan statistical areas present.

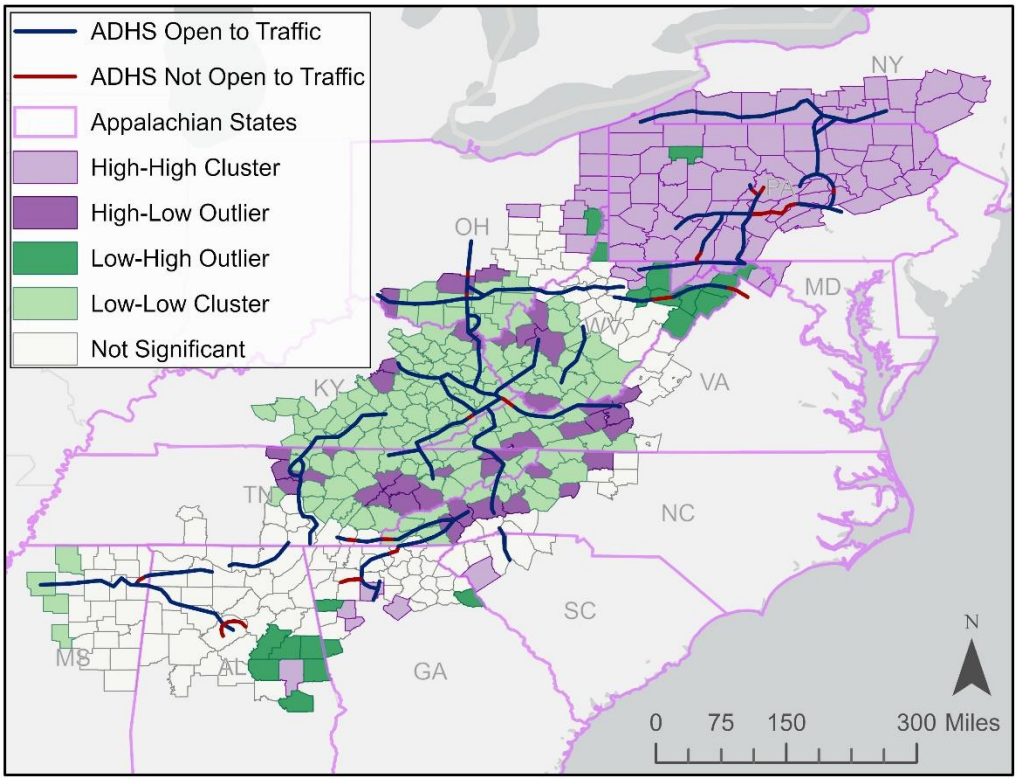

Figure 35: Cluster and Outlier Analysis of Per Capita Market Income in Appalachia and the ADHS in FY 2019. Generated by the author using data from the ARC's County Economic Status Report.

By FY 2019, the low-income cluster in Mississippi shrunk to include only four counties with incomes ranging from $17,941 to $21,124. The low-income cluster in central Appalachia spanned from Ohio to North Carolina, with the number of counties in the low income cluster in North Carolina increasing from 3 in FY 2013 to 13 in FY 2019. The incomes in this central

Appalachian cluster ranged from $9,752 to $24,097. High income outliers in this cluster ranged from $24,178 near Charleston, West Virginia to $41,210 outside Cincinnati, Ohio. Counties near Lexington, Kentucky, Knoxville, Tennessee, Asheville, North Carolina, and Radford, Virginia also exhibited higher incomes than the rest of central Appalachia.

The high-income cluster in New York, Pennsylvania, Ohio, West Virginia, and Maryland exhibited incomes from $24,388 to $44,794. A neighboring cluster of low-income outliers in the panhandle of West Virginia experienced incomes of $19,73 to $23,858. The only low-income outliers within the northeastern cluster were Forest County, Pennsylvania with a per capita market income of $15,440 and Jefferson and Marshall Counties in Ohio with per capita market incomes of $19,533 and $23,746, respectively. Most of the land in Forest County is protected as part of the Allegheny National Forest. The causes of lower incomes in Jefferson and Marshall Counties would be a topic for further study.

Spatial Trends in Poverty Rates

The spatial distribution of high poverty rates unsurprisingly coincided with clusters of high unemployment and low income. Areas around major cities exhibited lower poverty rates than rural areas. The Northeast consistently exhibited lower poverty rates than Central Appalachia and Mississippi, Alabama, and Georgia. Over the study period, the spatial distribution of poverty rates became increasingly extreme with most counties belonging to either a high or low cluster, and few areas with a concentration of typical poverty rates. There was no statistically significant difference in poverty rates for counties with ADHS roads versus those without ADHS roads.

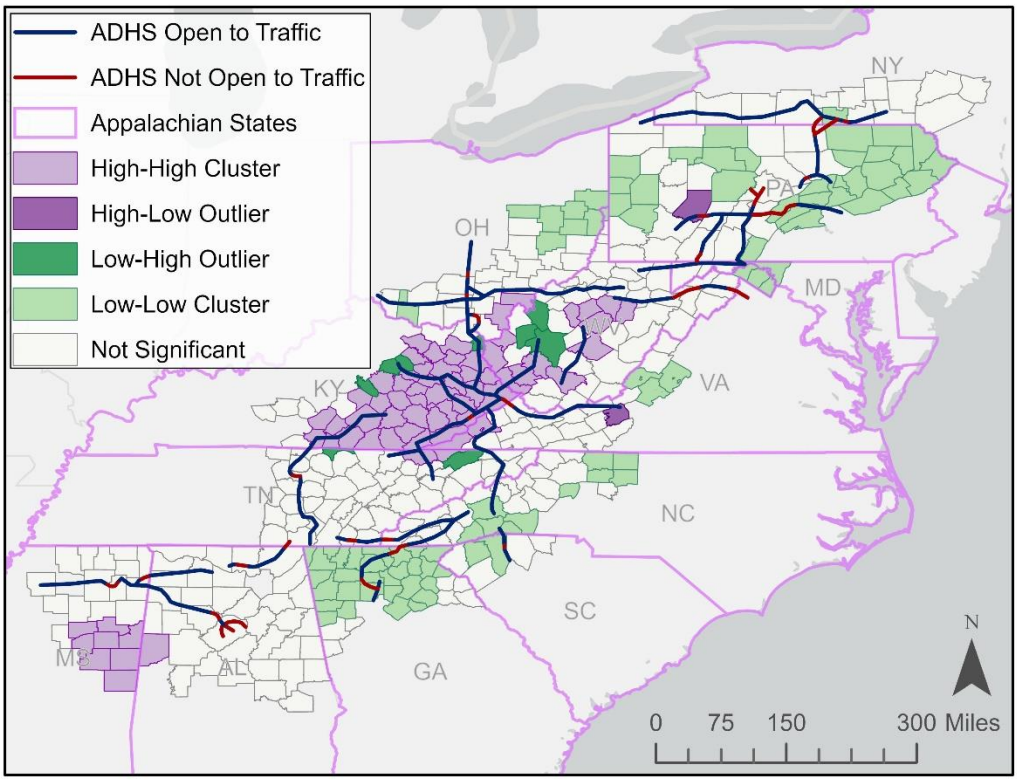

Figure 36: Cluster and Outlier Analysis of Poverty Rate Estimate in Appalachia and the ADHS in FY 2007. Generated by the author using data from the ARC's online data retrieval tool.

There is a high poverty rate cluster in Mississippi where 9 counties exhibited poverty rates between 19% and 33% in FY 2007. Counties in another high-poverty-rate cluster in Kentucky and West Virginia experienced between 17% and 45% poverty. Low-poverty outliers in Central Appalachia were near Lexington, Kentucky and Charleston, West Virginia. They experience poverty rates between 9% and 16%. Low-poverty clusters centered around Atlanta, Georgia, Greenville, South Carolina, Asheville and Greensboro, North Carolina, and Lexington, Virginia had poverty rates ranging from 5% – 16%. Eastern Ohio, Pennsylvania, and Maryland also exhibited low poverty clusters from 7% – 16%. The two high-poverty outliers were Montgomery County, Virginia, with 25% poverty and Indiana County, Pennsylvania, with 17% poverty.

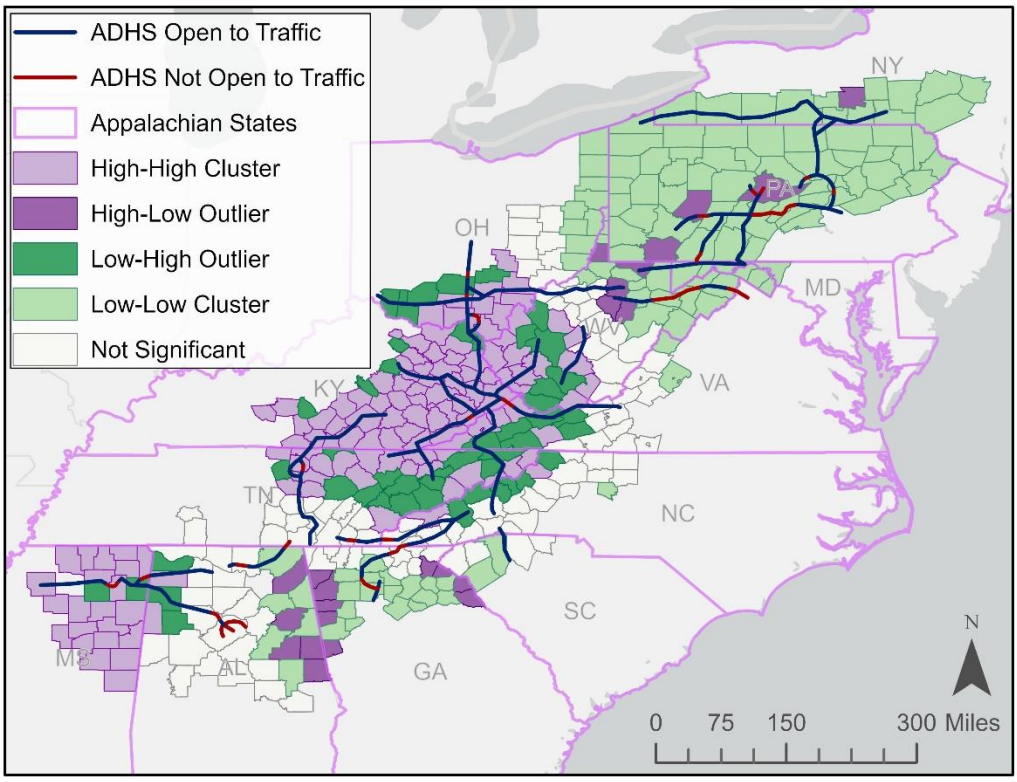

Figure 37: Cluster and Outlier Analysis of the Five-Year Poverty Rate Estimate in Appalachia and the ADHS in FY 2013. Generated by the author using data from the ARC's County Economic Status Report.

Poverty levels in FY 2013 rose to reflect the Great Recession, and the high-poverty clusters grew. In Mississippi and Alabama, the high-poverty cluster was comprised of 24 counties with poverty rates from 19% – 36%. Low-poverty outliers in this cluster included 5 counties with 13% – 18% poverty. Another high-poverty cluster in Central Appalachia grew to include Ohio, Kentucky, Tennessee, West Virginia, and parts of Virginia and North Carolina. Counties in this cluster exhibited poverty rates between 19% and 42%. A band of low outliers with poverty rates from 10% – 18% stretched from Charleston, West Virginia to Knoxville, Tennessee. Counties in southern Ohio between Cincinnati and Athens also fared better than the rest of Central Appalachia, with 9% – 16% poverty.

The low-poverty cluster spanning Birmingham, Alabama, Atlanta, Georgia, and Greenville, South Carolina was comprised of counties with 6% – 18% poverty. Notice that 6 counties in Alabama were part of this low-poverty cluster in FY 2013, while none of the counties in Alabama displayed poverty rates significantly lower than the mean for the region in FY 2007. New York, Pennsylvania, Maryland, eastern Ohio, northern Virginia, and the panhandle of West Virginia formed a low-poverty cluster, with the share of those living below poverty ranging from 8% – 18%. High-poverty outliers in central Pennsylvania and West Virginia exhibited slightly higher rates of poverty from 19% – 21%.

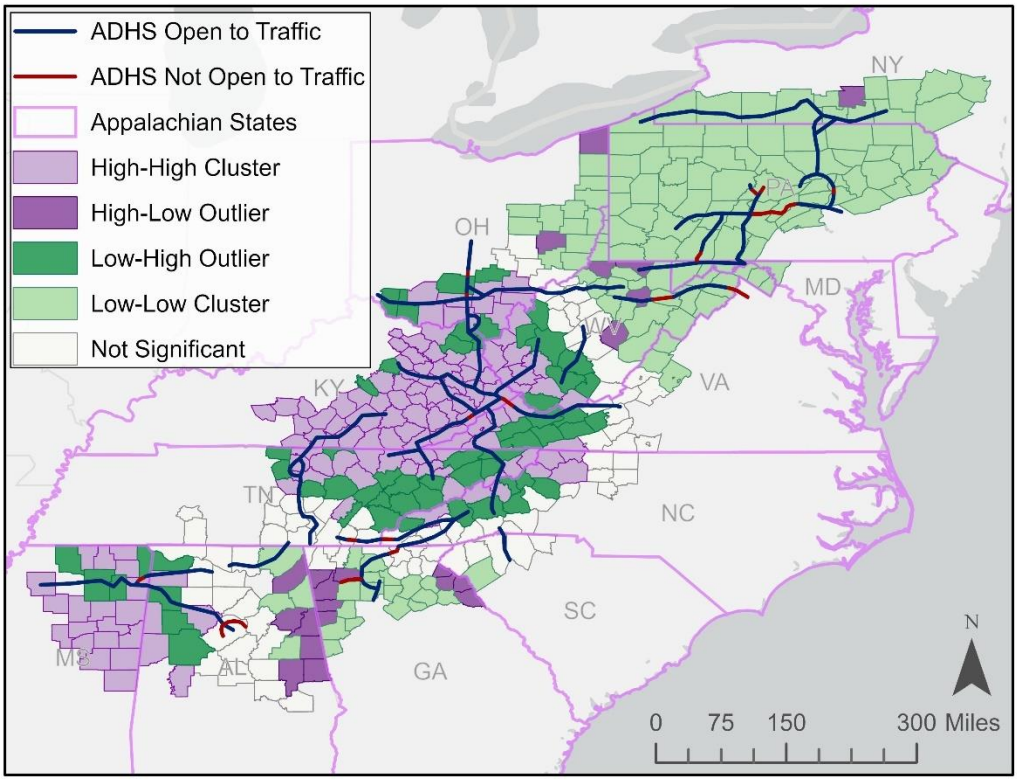

Figure 38: Cluster and Outlier Analysis of the Five-Year Poverty Rate Estimate in Appalachia and the ADHS in FY 2019. Generated by the author using data from the ARC's County Economic Status Report.

The spatial distribution of poverty rates in FY 2019 was similar to FY 2013, while overall poverty levels increased slightly for much of the region. The high cluster in Mississippi and Alabama ranged from 20% – 33% poverty. A cluster of 99 counties in central Appalachia exhibited 20% – 43% poverty, with low-poverty outliers from Charleston, West Virginia, to Knoxville, Tennessee and Asheville, North Carolina. These outliers exhibited poverty rates from 10% – 19%. There was a cluster of counties with low-poverty rates in Alabama, Georgia, and South Carolina where 6% – 19% of people were living below the poverty line. The high outliers along the east and west borders of Georgia had 20% – 25% poverty. Poverty rates in the Northeast remained low for the region, with a low-poverty cluster from New York to Virginia with 8% – 19% poverty and high outliers ranging from 20% – 27%.

Discussion and Conclusion

This study aimed to describe how economic trends in Appalachia from 2007 to 2019 differed from the nation during an unprecedented period of economic expansion. We relied on summary statistics to compare trends in unemployment, per capita market income, and poverty in the Appalachian region with the United States as a whole. We found that Appalachia performed worse than the rest of the nation in all indicators. Appalachian counties took longer to return to pre-recession levels of unemployment than non-Appalachian counties, and the share of counties with unemployment rates greater than two standard deviations above the mean for the country doubled. Per capita income in Appalachia decreased relative to national incomes, and income inequality within the region increased. Poverty levels increased while decreasing slightly relative to national poverty rates.

We also sought to identify trends in the spatial distribution of unemployment, per capita market income, and poverty changed from 2007 to 2019 using cluster and outlier analysis. The spatial distribution of each of the economic indicators followed a similar pattern in which Central Appalachia performed consistently worse than the Northeast on all indicators. Mississippi started with a cluster of high unemployment, low incomes, and high poverty in FY 2007. The cluster of high unemployment expanded to include western Alabama in FY 2013, but by FY 2019, Mississippi and Alabama exhibited unemployment rates typical for the region while poverty remained high. This suggests that the decrease in the unemployment rate in these states may be because individuals left the workforce, were underemployed, or employed in primarily low-wage jobs. This is supported by Krugman's (1994) hypothesis that increasing wage inequality is associated with lower unemployment.

We used spatial analysis to isolate counties in Appalachia that are a part of the ADHS system from those that are not and compared their economic performance using summary statistics. We did not find any statistically significant difference in any of the economic indicators for Appalachian counties with versus without ADHS roads. A better predictor of economic performance was the level of urbanization. Counties near major cities performed better than rural areas on all indicators. This supports the hypothesis that increased market access is associated with increased economic productivity as confirmed by Jaworski and Kitchens (2019), Alvarez-Ayuso et al (2016), Njoh (2012), Goetz (2011), Gibson and Rozelle (2003). Schmitt and Kramer (2010) caution that transportation investment leads to economic growth that differs across industries, and Kuştepeli, Gülcan, and Akgüngör (2012) offer the caveat that the evidence for economic growth as a result of infrastructure investment is stronger in the short run than the long run. Additional research should differentiate the role of transportation investment across industries in Appalachia and seek to isolate the short-run benefits of ADHS construction from long-run effects.

Further research should be conducted on the relationship between ADHS construction and economic performance. Over the FY 2007 – FY 2019 study period, there was little change to the ADHS system. Most of the AHDS roads were constructed prior to FY 2007. Only three counties that had no ADHS roads in FY 2007 were planning ADHS construction by FY 2019. Many ADHS construction projects that were planned to take place, like the Birmingham bypass known as Corridor X-1, were not completed. This study was unable to identify any short run stimulus provided by the minimal ADHS spending in the post-recession era. A longer study period going back to the initial construction of the ADHS would be more useful for understanding the role of transportation spending in economic development in the region. A

difference in differences regression model including additional economic indicators could be used to parse the effects of road construction from generalized economic growth.

Economic indicators reveal that much of Appalachia has not benefited from economic expansion to the same extent as the rest of the nation during the post-recession period. Poverty rates in Appalachia were consistently higher than the rest of the nation for the study period. While unemployment rates returned to their pre-recession levels by FY 2019, they remain higher in Appalachia than the rest of the nation. The share of counties with unemployment rates greater than two standard deviations above the mean doubled from FY 2013 to FY 2019. Incomes in Appalachia decreased relative to the rest of the nation while income inequality within Appalachia grew.

These data suggest that Appalachia continues to perform worse than the rest of the nation in these key economic indicators, while the growth that is occurring within the region is unequally distributed. Urban areas performed better than rural areas, and the Northeast performed better than central Appalachia. Future development strategies will need to account for the barriers to development in the most rural parts of Ohio, Kentucky, Tennessee, and West Virginia. Focusing on developing high-quality jobs and additional workforce training will be key to continuing to promote the development that is occurring in southern Appalachia.

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