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The Socioeconomic Impact of Coal in the Appalachian Region of Kentucky

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Executive Summary

The coal debate seems to be in a state of inertia. Proponents of coal claim the industry brings economic benefit to Kentucky. Environmentalists claim the industry creates irreparable harm to the Appalachian Mountain region. While these opinions are not unfounded, seldom do stakeholders explore the impact incurred directly in the Appalachian communities that mine coal. Moving the debate to a discussion about coal's direct impact in the communities that support the industry may broaden stakeholders' perspective. Determining whether the industry helps or harms the Appalachian community may be the break in the debate's stalemate. Thus, this paper explores the socioeconomic impact of the coal industry in Eastern Kentucky.

To measure the socioeconomic impact, the parameters of "socioeconomic" must be defined. For the purposes of this research, socioeconomic includes median household income, poverty rates and age-adjusted mortality. When median household income was measured against coal mining employment percentages, an inverse relationship was revealed; a 1 percent increase in coal mining employment could decrease median income by 152 dollars. Also, a direct impact was revealed between coal mining employment and poverty rates; when coal mining employment increased by one percent, poverty increased by .003 percent. Lastly, as coal mining employment increased by 1 percent, age-adjusted mortality increased by approximately 9 lives.

The issue of coal is no longer a normative topic of debate. Recent studies show that coal's presence in Eastern Kentucky is declining, both in terms of mineral reserve and employment opportunities. Stakeholders must acknowledge this potentially devastating economic event. An economic transition strategy is necessary to protect Appalachian economies from collapsing when the coal industry substantially declines. It is far more prudent to take measures now to ensure a smooth transition rather than wait for a collapse and plan for recovery.

Introduction

Coal is a hot topic of debate in the state of Kentucky. Any visitor to the state could notice the importance of the coal industry to the Commonwealth. Television advertisements, car stickers and billboards are outward displays of the on-going debate. Supporters of coal want to preserve the livelihood of a region, market freedom and social inheritance. This side of the argument is commonly supported by referencing the revenue collected by the state in the form of coal severance taxes; during the 2012-2013 fiscal year, the coal severance tax collected from coal companies totaled to $154 million dollars (Bailey, 2013).

On the opposite side of the argument, opponents cite concerns about the adverse effects of coal on the environment as pollutants are released and natural habitats are destroyed. One topic that is particularly important to this side of the debate is mountaintop removal. Many have argued that this process, although expedient for companies, leaves the environment compromised. Most notably, the water supply near mountaintop removal sites has recorded high levels of poisons, such as arsenic and lead. At one reading, a local water supply registered arsenic levels at 130-times what is considered safe by the EPA (House, 2011).

The passion of the debate is undeniable, but this passion can overshadow basic problems. Some of these issues are lost in the emotion of the debate. This paper will examine an often absent piece of this discussion by examining whether the delayed social development in Appalachian coal communities in Kentucky is attributable to coal production. While admittedly a narrow aspect of the overall coal debate, a review of the socioeconomic impact could have significant ramifications for public policy. This topic is of particular importance as policymakers often overlook coal's direct impact on the communities that actually mine the mineral. For example, Kentucky stakeholders often focus on the economic benefit of coal production for the state on the whole; however, the question is seldom narrowed to the coal mining communities. To this end, past studies relating to mortality, birth defects, education and employment are explored in this study. Additionally, data related to median income, poverty and age-adjusted mortality is presented. Based upon past studies and initial data collection, the hypothesis is that as coal's presence increases for a given county a negative impact is observed for income, poverty and age-adjusted mortality rates.

Problem Statement

According to recent government studies, the coal reserves in Eastern Kentucky are declining ("Annual Coal Report 2012"). As last measured, from 2011 to 2012, the overall reserve decreased approximately 12.2 percent. In conjunction with this decrease, government reports reflect a decrease in mining employment in Eastern Kentucky of 17.0 percent. By some accounts, it seems the market share of coal is shifting to the Interior and Western regions (Ward, 2013). Furthermore, the energy market is transitioning to cleaner and cheaper initiatives such as natural gas (Ward, 2013).

Some policy watchers are concerned that state and local leaders are not preparing coal communities for the seemingly inevitable decline of a significant economic contributor. It seems that if policymakers understood the current state of existence for the coal communities and the potential economic devastation in the future, they would be more open to discussing Eastern Kentucky's transition into a viable, more diverse economy. Since policymakers should be apprised of the many layers of a topic before making such crucial decisions, the goal of this paper is to provide additional information for policymakers to fill the gaps in the conversation that have been missing. Hopefully, a focused study on the direct impact on coal counties will encourage a broad perspective for the coal debate.

Literature Review

While the Appalachian region is no stranger to socioeconomic disadvantage, it seems that coal regions are particularly plagued with these struggles (Goodell, 2007). According to the Appalachian Regional Commission, a relationship exists between coal-dependent economies and undiversified economies, fewer professional service employment positions and lower educational attainment (Wood, 2005). Perhaps even more troubling, studies have shown that coal mining communities have higher mortality rates (Hendryx, 2008). Mortality is a significant factor to consider in any discussion of socioeconomic standing. To this end, the Universities of West Virginia and Washington State collaborated to evaluate the costs and benefits of the coal industry, specifically in Appalachia (Hendryx and Ahern, 2009). The study approached the issue of coal in a manner atypical of the Appalachian coal discussion; the study incorporated the value of life lost associated with the coal industry. Many of the problems that plague the Appalachian community, such as disparity of professional services and low educational attainment, are commonly associated with the region's undiversified economy. The Hendryx and Ahern study goes beyond the measure of traditional economic indicators. While some empirical studies have shown that health disparities in Appalachian coal counties exist at rates higher than other populations, the Hendryx and Ahern study highlights the alarming mortality rates in coal-producing areas. Mortality rates in Appalachian coal mining areas are not only higher than national averages, but also higher than their non-mining Appalachian counterparts.

Although coal is a core economic effort in Appalachia, researchers hypothesize the cost of coal potentially outweigh the benefits. To evaluate this proposition, Hendryx and Ahem (2009), analyzed four different groups: (1) Appalachian counties mining coal at levels above the median production levels; (2) Appalachian counties mining coal at levels below the median production levels; (3) Appalachian counties not mining coal; and (4) other counties in the United States (Hendryx and Ahern, 2009). Then, the researchers converted mortality data to a monetary unit by applying a Value of Statistical Life (VSL) rate based upon the research of various U.S. regulatory agencies. The VSL compares the risk associated with an activity to the cost of reducing such risk. Once these values were calculated, they were further converted through Consumer Price Index (CPI) estimates. After adjusting for mortality factors unrelated to coal mining specifically, the cost calculated was approximately $18.166 billion per year. This cost, standing alone, does not have much value to the analysis. To serve as a comparator, the study calculates the economic benefit of the coal industry in the Appalachian Region.

To assess the economic benefit of the coal industry, a formula was created to reflect the direct and indirect economic contributions, induced contributions and severance tax collections, less tax credits. The result of this calculation was approximately $8.088 billion per year in economic benefit. Thus, the net effect was approximately -$10.078 billion (Hendryx and Ahern, 2009).

Furthermore, the researchers relied on prior research to narrow the scope of certain socioeconomic indicators to assess correlations to the coal industry. The selection of socioeconomic indicators was based upon characteristics that have traditionally explained the plight of Appalachia, such as median household income, poverty rates, educational attainment and unemployment rates (Hendryx and Ahern, 2009). The results demonstrated that not only did coal-producing counties in Appalachia appear to be "worse off" in terms of these selected socioeconomic variables, but also, as production levels of coal increased in a county, the level of socioeconomic disparity also increased. Additionally, it was discovered that the levels of poverty and unemployment were not statistically higher in non-mining Appalachian areas as compared to other regions across the nation. Lastly, the data revealed that heightened levels of mortality in Appalachian coal-mining counties were not exclusive to males (Hendryx and Ahern, 2009). As coal miners are predominately male, the excessive life lost does not seem to be explained merely by the industrial hazards of mining; the research suggests that air and water pollutants, as byproducts of coal mining production, are factors that explain the poor health conditions in Appalachian coal counties.

The health of the communities that mine coal is also a significant piece of this discussion. While mining is an inherently dangerous industry, the health effect is not isolated solely to coal miners. For example, low birth weights have been correlated to coal mining (Ahern et al., 2011). This could be explained in part by pollutants released in the water supply and air during mining; such pollutants include heightened levels of sulfate, calcium, magnesium and hydrogen sulfate (Palmer, 2010). To illustrate that these effects are not limited to miners, fetal deliveries have been studied, and the following impacts have been recorded: gene mutation, orofacial clefts, limb reduction, gastrochisis and congenital heart disease (Ahern et al., 2011). A specific article was examined for its analysis of birth defects in Appalachian coal mining counties (Ahern et al., 2011). Based upon past studies in China, which uncovered a statistically significant relationship between proximity to coalmines and neural birth defects, the authors of this article hypothesized that the rate of birth anomalies would be greater in mountaintop-mining areas as compared to other mining and non-mining areas. First, in order to understand the impact of mountain-top removal, the process itself may require an explanation. In this process, coal companies cut down forests, remove mountain peaks, dig into the surface, remove coal and cover the "hole" before leaving. Mountain peaks are essentially reduced to a plateau. Mountaintop removal is a process that is practiced in Kentucky; thus, the outcomes of the study demonstrate the potential harms to Kentucky residents (House, 2011).

In order to test their hypothesis concerning mountain-top removal, the researchers relied on data from the National Center for Health Statistics, which maintains data for every live birth in the United States (Ahern et al., 2011). This data helped the researchers compile information about birth defects in Appalachia and measure certain indicators such as age, race, mother's education, prenatal care and per capita primary physicians and obstetrician-gynecologists. The study found that mining and mountaintop reported areas produced higher incidents of birth defect. Additionally, the rate of birth defect was higher in mountaintop removal areas compared to other mining areas. The researchers concluded that a potentially strong relationship between birth defects and residency in an area that conducts mountaintop removal (Ahern et al., 2011).

Lastly, as one may suspect, poverty is an on-going concern in the Appalachian region. According to the Appalachian Regional Commission, Central Appalachia reports higher poverty rates as compared to other Appalachian regions (Ross, 1999). Syracuse, the University of Colorado and the University of Maryland conducted a study to test the Human Capital Theory in terms of secondary educational attainment (Black et al., 2005). The researchers focused a portion of their study on the Appalachian coal community. The theory explains that furthering one's education, in this analysis a high school diploma, depends upon the cost/benefit analysis of expected returns. If the earnings associated with a higher degree outweigh the opportunity cost of entering the workforce immediately, the student will remain in school; otherwise, the student will leave school and enter the workforce. The researchers cite previous studies that indicate that as the wages of low-skilled workers increase, the high school completion rates decrease. In particular, the researchers wanted to measure the effects of "shocks," or the highs and lows of the coal market, on human capital.

To study the Human Capital Theory in coal communities, the researchers were particularly interested in the coal boom of the 1970s and the bust in the 1980s. Before the coal boom, the Pike County community only earned 56 percent of the national per capita income; during the coal boom of the 1970s, the level increased to 90 percent of the national average. However, when the industry busted in the early 1980s, the per captia income dropped down to 63 percent of the national average. Additionally, research revealed that the majority of coal workers have lower educational attainment. The industry bust essentially nullified any wage gains, setting the wages back to their original values. Therefore, the researchers believed this was an ideal market to test the theories, and in so doing, revealed consequences within the coal communities (Black et al., 2005).

To test the applicability of the Human Capital Theory in Appalachian coal communities, the authors began by dividing the data into three different categories: (1) Big Coal counties, meaning at least one billion tons of coal reserves; (2) Medium Coal counties, meaning those with at least 100 million tons but less than 1 billion tons; and (3) Low Coal counties, meaning those with less than 100 million tons in coal reserves. As predicted, the high school enrollment rate decreased in Big Coal counties, as compared to the Low Coal counties, when the coal boom was in full swing (Black et al., 2005).

Researchers predict that the effects of an increase in wages during a boom will only be temporary; the long-term effects of a boom will not sustain benefits to the worker for choosing to leave high school (Black et al., 2005). Researchers found that no statistically significant relationship existed between earnings per worker and high school enrollment rates; from this result, the researchers inferred that short-term shocks do not substantially affect overall high school enrollment. The second results were statistically significant. The finding showed that each 10 percent increase in coal workers' wages reduced high school enrollment 6.5 percent. Additionally, the research discovered that the amount of coal reserve in a county was a strong indicator of high school enrollment (Black et al., 2005).

These studies certainly have applicability to Kentucky, but they do not specifically focus on Kentucky data in their conclusions. These articles gave guidance for the variable collection and the methodology of this project, however, these articles alone do not explain the potential policy concerns Kentucky leaders face. Focusing the study to the state gives the findings more credence in the Kentucky coal discussion.

Research Design and Findings

Variable Collection

In a broad sense, the goal of the project is to compare Kentucky's Appalachian coal mining counties to Kentucky counties that do not directly participate in the mining industry. The focus is the state itself, and while comparing Kentucky to other states within and outside the Appalachian region could prove noteworthy (as is demonstrated in the aforementioned Hendryx studies), the approach taken in this project reveals information specifically related to the Kentucky coal industry. As previously stated, it is hypothesized that Appalachian coal mining correlates to lower socioeconomic outputs. To begin the study, it was paramount to have coal production variables. Again, the suspicion is that as coal's presence increases for a given county, the socioeconomic characteristics decrease. Coal production and employment levels were available through the Kentucky Energy and Environment Cabinet. These variables were available per county for nearly a hundred years. As other variables were collected, it was clear that a hundred years of data is unique. To conform to the availability of other variables, this list was narrowed to the years 2000-2010.

To set the parameters of "socioeconomic" is difficult; the term is not inherently defined. Because the Hendryx study had similar a hypothesis, it was consulted for guidance on variable collection. Hendryx considered age-adjusted mortality rates, coal employment and production, certain socioeconomic characteristics such as median household income, poverty rates, high school and college educational attainment and unemployment rates; these variables were likewise considered for this study. Additionally, Hendryx included smoking rates. This project was unable to obtain county-level smoking data for Kentucky.

Like the Hendryx study, mortality was a key concern for this study. From a normative standpoint, mortality is a variable that most people would agree should not vary; in an ideal world, differing areas of the United States would not experience higher rates of death. Additionally, indicators of income were of interest for this study. As Hendryx discussed, the presence of the coal industry does not mean an economic benefit exists. In Kentucky, many argue that coal positively impacts mining communities directly by providing employment opportunities.[1] This study empirically examines these claims. Therefore, median income and poverty rates were also included in the study.

Next, specific socioeconomic variables for each Kentucky county were collected from the Kentucky Energy and Environment Cabinet. Specifically, a data set provided the following information per county per year: total coal mining employment, coal production, total labor force, total unemployment rate, median income and population. A coal employment percentage was generated based upon the coal employment and total labor force variables provided by the Cabinet. While coal production levels measured in the thousand ton were available, it seemed that employment percentages reflect a more accurate picture of the industry. Production has increased over time, but employment does not always follow that trend. Through technological advances, companies have

[1] http://www.facesofcoal.org/index.php?u-s-coal-and-kentucky

increased productivity and thereby reduced the labor force. The purpose of this project is to measure socioeconomic factors of these communities. Production levels would be important to an analysis that focused on the coal companies alone, but the focus of this project is the impact of coal production in Eastern Kentucky. Similarly, a conversion was necessary to measure poverty. Crude poverty numbers were collected from the Kentucky Data Center, but rather than measure these crude numbers across counties, these variables were converted into a poverty rate. The rate allows for comparison that seems more explanatory than raw numbers.

Lastly, educational attainment was identified as an important element of the study. While many agencies define "educational attainment" differently, two methods seem to prevail. Most agencies report the attainment of 1) high school diploma or equivalent and 2) 4-year degree or higher. The U.S. Census Bureau provided most of the data for this variable. To supplement this data, the Kentucky Council on Post Secondary Education provided information for some of the missing years. For the counties that had missing data, estimates were assigned based upon the static nature of educational attainment. Table 1 represents the collected data.

Table 1: Description of Variables

Variable Name	Value Label	Variable Label
County Code		Numeric code for each KY county
Population		Crude population
Number in Poverty		Crude count of poverty
Median Income		Median income per household
Age-Adjusted Mortality		Mortality adjusted for age; reflects rate per 100,000
Mining Employment		Crude count of mining employment
Total Employment		Total employment for all industries
Unemployment Rate		Unemployment rate
Diploma		Percentage who have obtained high school diploma or equivalent
Bachelor Degree		Percentage who have obtained 4-year degree or higher
Poverty Rate		Percentage of population living in poverty
Coal Mining Percent		Percentage of employment in mining

Additionally, some variables reflect a crude number, while others reflect a rate or percentage. In order to adequately interpret the data, Table 2 can be used as a guide. Table 2 shows that age-adjusted mortality, unemployment rate, educational attainment (both diploma and bachelor degree variables), poverty rate and coal mining percent are presented in ratios, rather than crude numbers. This differentiation is crucial in interpreting the analysis. Additionally, please note, the age-adjusted mortality rate is reported per 100,000 people.

Table 2: Descriptive Statistics

Variable Name	Observations	Mean	Standard Deviation	Minimum	Maximum
County Code	1320	60.5	34.65294	1	120
Population	1320	34830.23	70136.13	2183	741096
Number in Poverty	1320	5589.111	9687.027	390	125861
Median Income	1320	34396.87	9192.54	16435	84884
Age-Adjusted Mortality	1320	1001.031	141.092	645.6	1588.4
Mining Employment	559	182.3989	550.9536	0	347506
Total Employment	1320	15576.13	33549.61	925	347506
Unemployment Rate	1320	7.295152	2.476165	2.8	19.6
Diploma	1320	.3675219	.0530181	.088	.584
Bachelor Degree	1320	.1172436	.0589319	.007	.394
Poverty Rate	1320	.1866451	.0679162	.0431682	.4479321
Coal Mining Percent	559	.0180008	.0466714	0	.240519

Method

First, a fixed effects model was formulated; the level of analysis for this method was the county. Since fixed within effects measures within a unit of analysis, it is utilized to measure effects that can have a somewhat immediate impact. For example, the fixed within effects model is used to measure median income when the percent of coal mining employment increases. As coal represents a substantial portion of some Appalachian economies, an increase in the industry’s employment could reveal an impact from year-to-year; a change in employment could impact median income within a year. However, other variables have a lagged effect, and therefore, need to be measured across counties. The between effects model allows analysis for impacts that may not be revealed within this limited time frame. For example, poverty is a rate set by the federal government and uses comparative factors, such as Consumer Price Index-adjusted cost of minimum food diet, pre-tax cash income and family size.[2] The Appalachian Region has historically struggled with poverty, as evident by the 50th anniversary of the War on Poverty and its efforts to combat poverty in the Region.[3] So, it seems that gradual changes in coal employment may not be adequately reflected in a fixed within effects model. However, a between effects model analyzes across Kentucky counties. The analysis shows how coal affects counties that mine coal in Appalachia versus counties that do not mine. Therefore, as coal employment changes across counties, rather than within a county, changes in poverty are likewise measured. Similarly, consider the variable age-adjusted mortality. If a change in mortality is due to environmental pollutants, it is unlikely that the results would have an immediate, measurable effect.

First, a fixed effects model was formulated; the level of analysis for this method was the county. This method was selected based upon the collection of data; since data was collected from 2000-2010 for each county, a time-series regression was needed to reflect the change over time. The fixed effects model removes time-invariant qualities in order to glean a net effect (Torres-Reyna). A time variable was added to the formula in order to control for invariant correlations between the dependent and independent variables. The formula for a fixed effect model is as follows:

2 http://www.irp.wisc.edu/faqs/faq2.htm

3 http://www.usatoday.com/story/news/nation/2014/01/25/war-on-poverty-50th-anniversary/4326109/

$$Y_{it} = \beta_1 X_{it} + \beta_2 X_{it} + \beta_3 X_{it} + \alpha_i + u_{it}$$

Where Y_{it} represents the dependent variable (median income); $\beta_1 X_{it}$ represents the coefficient for rate of coal mining employment; $\beta_2 X_{it}$ represents the coefficient for obtainment of a high school diploma or equivalent; $\beta_3 X_{it}$ represents the coefficient for obtainment of a 4-year degree or greater; α_i represents the unknown intercept for each county; u_{it} represents the error term, which in a fixed effect model assumes that unique attributes are not random variation and do not vary across time.

To state the model in application, for a given county, as the independent variable varies across time by one unit, the dependent variable increases or decreases by the equation's coefficient. When median income was inserted as the dependent variable, the variable coal mining percent, which reflects the percentage of employment that is dedicated to mining, had a statistically significant impact. The analysis demonstrates an inverse relationship between rate of coal mining employment and median income.

Table 3: The Fixed Effects Measure of Coal on Median Income

Median Income	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf. Interval]**	
Coal Mining Percent	-152.3171	70.23912	-2.17	0.031	-290.3673	-14.26681
High School Diploma	19.44099	17.21725	1.13	0.259	-14.39835	53.28034
Bachelor Degree	101.511	39.20919	2.59	0.010	24.44799	178.574
_cons	301.0735	13.794	21.83	0.000	273.9624	328.1847

*Observations: 559; R–Squared within = 0.2953
** Although omitted from this table, a dummy variable for time was included in the regression.
***For convenience in interpretation, values adjusted from ratios

For each additional 1% increase in the mining employment market share, median income decreases approximately $152. To apply the results to an actual county, consider Harlan County, which reported a median income of $28,503 for the year 2010. If mining employment increased by 1% and all else remained equal, the income would likely fall to approximately $28,351.[4] This finding shows that when the county market is less reliant on coal for employment, median incomes are higher. Perhaps this is an indication of an undiversified economy. When a local economy has many employment options, the local citizenry benefits.

The fixed within effects model only analyzes within the unit of analysis, which is the county in this study. In order to compare among the counties, the method was altered to a between effects model. In the first between effects model, the dependent variable was poverty rate while the independent variables included coal mining employment rate, educational attainment (high school diploma or equivalent and 4-year degree or higher) and unemployment rate. The formula is as follows:

$$Y_{it} = \beta_1 X_{it} + \beta_2 X_{it} + \beta_3 X_{it} + \alpha_i + u_{it}$$

Where Y_{it} *represents a dependent variable that reflects the percentage of the population living in poverty;* $\beta_1 X_{it}$ *represents the coefficient for rate of coal mining employment;* $\beta_2 X_{it}$ *represents the coefficient for obtainment of a high school diploma or equivalent;* $\beta_3 X_{it}$ *represents the coefficient for obtainment of a 4-year degree or greater;* α_i *represents the unknown intercept for each county;* u_{it} *represents the error term, which in a fixed between model assumes that unique attributes are not random variation and do not vary across time.*

To state the model in application, for a given county, as the independent variable varies across time by one unit, the dependent variable increases or decreases by the equation's coefficient. When poverty rate was inserted as the dependent variable, the variable coal mining percent, which reflects the percentage of employment that is dedicated to mining, had a statistically significant impact. The analysis demonstrates a direct relationship between rate of coal mining employment and poverty.

[4] Based upon employment estimates from the Energy Cabinet, an additional 95 jobs would increase total mining employment from 1,979 to 2,074. This increase would alter the market share of employment opportunities from 20.76% to 21.76% share of mining employment.

Table 4: The Between Effects of Coal on Poverty

Poverty Rate	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Coal Mining Percent	.00295259	.000864713	3.41	0.001	.001238213	.004666967
High School Diploma	-.006627707	.001076226	-6.16	0.000	-.00876142	-.00449398
Bachelor Degree	-.005664378	.000984516	-5.75	0.000	-.007616277	-.300712479
Total Unemployment Rate	.000174127	.00003379	5.15	0.000	.000107136	.000241119
_cons	.003621809	.000655441	5.53	0.000	.002322333	.004921286

*Observations: 559; R-Squared between= 0.6709
**The dummy variable for time was omitted from this model; it demonstrated no statistically significant impact.
***For convenience in interpretation, values adjusted from ratios

The results show that an additional 1% in mining employment increases the percentage of the population living in poverty by approximately .003%. This finding is somewhat counterintuitive. One would suspect that employment brings more economic benefit. In this analysis, mining employment is measured as a percentage of total employment. For example, coal miners represent approximately 18% of Pike County's labor force; additionally, roughly one in four citizens live in poverty. If coal-related jobs increased in the county to account for an additional .5% of the labor force (which would be an additional 118 jobs all things equal), an additional 4 citizens would live in poverty.[5] It seems that a diverse employment base would be beneficial to areas like Pike County. These results should encourage state and local policymakers to pursue initiatives that diversify the local economies where mining represents a portion of the employment sphere. As previously discussed, reports from the Energy Information Administration show a decline in the Central Appalachian coal reserves. Furthermore, reports predict that

[5] Based upon employment estimates from the Energy Cabinet, an additional 118 jobs would increase total mining employment from 4,390 to 4,508. This increase would alter the market share of employment opportunities from 18.70% to 19.2% share of mining employment.

coal mining will shift to the Interior and Western regions of the United States (Ward, 2013). As the industry declines in Kentucky, local leaders should transition these counties into a new economic strategy.

The second analysis follows the previous between effects model, but age-adjusted mortality[6] was inserted as the dependent variable while keeping the same independent variables as the previous model. The formula for this model is as follows:

$$Y_{it} = \beta_1 X_{it} + \beta_2 X_{it} + \beta_3 X_{it} + \alpha_i + u_{it}$$

Where Y_{it} represents the dependent variable (age-adjusted mortality); $\beta_1 X_{it}$ represents the coefficient for rate of coal mining employment; $\beta_2 X_{it}$ represents the coefficient for obtainment of a high school diploma or equivalent; $\beta_3 X_{it}$ represents the coefficient for obtainment of a 4-year degree or greater; α_i represents the unknown intercept for each county; u_{it} represents the error term, which in a fixed between model assumes that unique attributes are not random variation and do not vary across time.

The analysis shows a direct relationship between coal and age-adjusted mortality; when coal represents a larger portion of a county's work force, age-adjusted mortality increases. Specifically, the findings show that for each additional 1% in mining employment, age-adjusted mortality increases on average by 9.56 lives per 100,000 people. This result could reflect pollutants in the local environs or overall socioeconomic hardships; either way, the result is troublesome.

[6] Where age-adjusted mortality is calculated by: [(Deaths in Age Group)÷(Estimated Population of Age Group)] * 100,000

Table 5: The Between Effects of Coal on Age-Adjusted Mortality

Age-Adjusted Mortality	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Coal Mining Percent	9.568579	1.760061	5.44	0.000	6.079087	13.05807
High School Diploma	-7.138658	2.190581	-3.26	0.002	-11.4817	-2.795618
Bachelor Degree	-9.995054	2.003913	-4.99	0.000	-13.96801	-6.022102
Total Unemployment Rate	.1720399	.06877635	2.50	0.014	.03568409	.3083957
_cons	12.02002	1.334104	9.01	0.000	9.375025	14.66501

*Observations: 559; R-Squared between = 0.5801
**The dummy variable for time was omitted from this model; it demonstrated no statistically significant impact.
***For convenience in interpretation, values adjusted from ratios

To apply this finding to a specific Kentucky county for applicability, consider Perry County. For the last year of record, Perry County reported an age-adjusted mortality rate of approximately 1,377; for that year, the national age-adjusted mortality reported by the same agency was 746.[7] These figures control for age so that the same frame of population can be measured without any skewing for age. In theory, if an additional 1% of mining employment was present in the county for 2010 (which is approximately 103 additional jobs if all else remains equal), it is likely that the mortality rate would have risen by approximately 9 additional lives.[8] These results could reflect mining-related accidents or pollutants in the environment.

Limitations

To begin, this project is limited by the history of the Appalachian region. Sociologists in the late 1890s described Appalachia as a region of “egalitarian self-

7 http://www.cdc.gov/nchs/data/nvsr/nvsr60/nvsr60_04.pdf

8 Based upon employment estimates from the Energy Cabinet, an additional 103 jobs would increase total mining employment from 2,294 to 2,397. This increase would alter the market share of employment opportunities from 22.14% to 23.14% share of mining employment.

sufficiency" (Pudup, 1989). Without commercial activity, the region lacked capital means for progress. In addition to the weak local commercial activity, other factors further created an isolated environment for the Appalachian region. Beyond issues of commerce, transportation deficiency isolated the mountainous region of Eastern Kentucky from the rest of the state. Central Kentucky was settled earlier than the mountain region and thus began development sooner; it became the center of political and economic strength in the state. This imbalance in power manifested in state policies that favored financial support for development in the Bluegrass Region but not the Appalachian Region. These factors establish a unique history within Appalachian coal counties that cannot be completely controlled for in a regression model. While the research for this study reflects statistically significant results, one should be aware that the unique Appalachian culture cannot be completely controlled for a study set in a ten-year time frame.

Also, for educational attainment, some observations were missing from the original data set. After consulting the U.S. Census Bureau and Kentucky Council on Post Secondary Education, data was missing for 2001 through 2004. Because of the static nature of the variable, estimates were projected for these missing years based upon the linear trend of the available data.

Additionally, missing variable bias is a possible limitation to this study. One particularly desirable variable, smoking tobacco rates, is missing from this analysis. Smoking rates are not reported at the county level for the needed time period, 2000-2010. Furthermore, it is possible that variables were overlooked in the initial planning process, and thus, are missing from the results of this analysis.

Lastly, as is true with nearly all panel set data, research cannot construe these counties in the alternative; meaning, the results are limited in their ability to explain causation. If the Appalachian Region never had a coal industry, it is difficult to know how the county data would differ if coal never took root in the area. This analysis does not prove that coal alone is the cause of lower socioeconomic standing in Eastern Kentucky. This project only shows that recent data indicate a relationship between coal and lower socioeconomic standing.

Conclusions

The goal of this project was not to advocate for a political position. The intent was to contribute information that has been missing from the discussion. The benefits of coal for Kentucky on the whole often overshadow the issues created by coal. If policymakers make coal-related decisions based upon its benefits, the decision could be swayed by an inaccurate representation of coal's overall impact. In order to achieve the best results, policymakers need complete and accurate information, and this project hopes to further that goal.

Among other factors, researchers have analyzed the effects of coal mining on mortality, birth defects and educational attainment. These studies reflect a negative impact on the communities that mine coal. While these studies have applicability to Kentucky, the work does not directly represent the effect of coal within the state. Thus, this project considers similar variables of socioeconomic standing but narrowed the scope to Kentucky.

For the fixed within effects model, the data reflected a statistically significant relationship between median income and percentage of mining employment. For the between effects models, the results reported similar findings; coal mining employment revealed a negative impact on the communities when measuring poverty and age-adjusted mortality. Although coal supporters believe the industry adds value to the Appalachian region, this report does not review the positive aspects within the cost/benefit analysis of the coal discussion. These findings should supplement policymakers' discussions about the costs of the coal industry in Kentucky.

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