The Impact of Coal Activity on Local Revenues for Elementary and Secondary Education in Appalachia

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Executive Summary

This report is the second of two reports exploring the relationship between coal activity and funding for elementary and secondary education. The first report provided a descriptive analysis while this report examines the impact of changes in coal employment or production on local revenues for education using an econometric analysis. Coal employment in the U.S. has significantly decreased over the last century due to multiple factors. However, there is still great variation in trends in coal employment across regions, counties, and time. Some areas have experienced growth in coal employment while other areas have experienced significant declines in coal employment. These changes in coal activity can impact the fiscal health of communities, which can impact communities' ability to make adequate investments in education and training, an essential component for economic development. Local changes in coal activity can impact funding for education through a number of potential different mechanisms, which are discussed. While it can be unknown how these different factors impact local schooling support, this research focuses on how variations in coal activity impact local revenues for education.

Using annual data that spans from 1995 to 2016 and fixed effects regression models, we find that increases in coal activity have a positive and significant impact on local revenues for education per student. Specifically, results indicate that if coal employment increases by 100 workers, then local revenues per pupil will increase by $54, which represents 1.4 percent of the mean of local revenue per pupil for Appalachian counties. Results are consistent across different measures of coal activity, such as coal employment, coal production, number of coal mines, and coal employment as a share of total employment, and findings are consistent across different specifications. One statistical concern discussed is that counties may differ in unobserved characteristics over time that affect economic and fiscal conditions, and these characteristics may also be correlated with historical and current intensity of coal mining and the emphasis placed on education. If this is the case, then the relationship between coal activity and school funding may not be a causal relationship. Encouragingly though, results from identification strategies to address this endogeneity concern are consistent with baseline findings. Together, findings demonstrate the importance of coal activity to local communities in terms of their ability to invest resources in their future through funding for elementary and secondary education.

Introduction

In 1930, there were 644,006 coal miners in the U.S. By 2019, the number of coal miners had decreased to 81,361.[1] An industry that once provided high-paying jobs and helped foster economic and fiscal gains for host communities has little prospect of a broad and widespread resurgence though some pockets of strength will likely be sustained across the country. The long-term decline of national coal employment is due to multiple factors, including technological advancements such as autonomous trucks, drills, and conveyor belts that have displaced workers. Market forces and increasing competition are contributing factors as well. A recent example is the development of hydraulic fracturing and horizontal drilling in the oil and natural gas industry, which has led to lower prices for natural gas, a competing energy source. Finally, initiatives and regulations that aim to lower emissions such as the Clean Air Act and the Clean Power Plan, along with attendant environmental concerns on the part of some households and businesses, have diminished the demand for coal. While these factors have contributed to an overall decline in coal employment, the trends in coal employment have varied across regions, counties, and time. Some areas have experienced significant declines in coal employment which have been devastating to local communities while other areas have actually experienced growth in coal activity. Even in hard hit Appalachia, there remain vibrant pockets of coal mining activity.

Changes in the economic base resulting from shifting fortunes in the coal industry can have a material effect on the ability of local communities to provide public services that affect community wellbeing, including elementary and secondary education. This is especially important in poor communities in Appalachia where the narrow and fragile economic base translates into a weak and often unstable tax base. Fiscal stress arising from a volatile and potentially declining coal sector can hamper the ability of communities to make adequate investments in education and training—what economists refer to as *human capital*. Insufficient investments in education simply entrench the problem and hurt future economic growth prospects. In this paper, which is the second phase of a two-part research agenda supported by the Appalachian Regional Commission, we use regression analysis to examine how coal activity, including growing and declining employment, has impacted the provision of local revenues for elementary and secondary education from local own-source tax bases like the property tax.

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[1] For historical data on coal employment, see U.S. Department of Labor, Mine Safety and Health Administration (MSHA): https://arlweb.msha.gov/stats/centurystats/coalstats.asp

A change in coal employment and/or production could potentially impact local revenues for education through any of a number of channels. An increase in coal employment results in a direct economic impact to the community through growth in wages and salaries, in turn supporting expansions in local income, sales and property tax bases (depending on the revenue structure of communities). Growth in production helps foster a coal-industry supply chain that has similar effects. In contrast, a decline in coal employment or production will lead to a contracting economic base and thus a contracting local tax base. As tax bases evolve over time, communities choose tax rates and revenue streams to fund locally-provided services based on resident *tastes* for public services. These tastes or preferences are very important in determining funding levels, in rich and poor communities alike. If community residents highly value a local public service, they will tend to support higher tax rates and funding levels, even if they have little own-source revenue raising capacity (i.e., even if they are relatively poor). If a public service is not highly valued by local residents, they will tend to choose lower tax rates and lower levels of funding.

Together it is the local economic base interacting with the local tax structure (defined in part by state statute), along with voter choices expressed through referenda and majority voting that shape local spending support for elementary and secondary education. In practice, it is unknown how each factor contributes to local schooling support. However, it is possible to isolate the way in which variations in coal activity at the county level influence local spending outcomes. This is the goal of the current research.

Natural Resource Base and Education

Several studies have examined how changes in the demand for natural resources have impacted educational outcomes or education finances, with most recent studies focusing on the introduction of hydraulic fracturing. Results are mixed as to whether fracking has negatively or positively impacted property values (Bartik et al., 2019; Muehlenbachs et al., 2015; Gopalakrishnan and Klaiber, 2013). This is an important issue since the property tax base is the largest local revenue source for funding elementary and secondary education in the U.S.[2] Other work has specifically examined the impact of fracking directly on education finances, finding increases in local revenues per pupil. However, these increases were either offset by negative effects on state and federal aid (Cascio and Narayan, 2020) or effects were heterogenous across regions (Ratledge and Zachary, 2017). Some research has examined

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[2] See Davis and Ferreira (2017) for a recent examination of the impact of housing booms on increases in public education spending.

how demand for natural resources impacts enrollment, educational attainment, and teacher quality (Cascio and Narayan, 2020; Kumar, 2017; Marchand and Weber, 2020; Morissette et al. 2015; Rickman et al., 2017). All of the aforementioned papers examine unconventional oil and gas booms following the development of fracking, and findings do not necessarily extend to the context of other resources, including coal booms and busts. An exception is Black et al. (2005b) who finds that higher earnings associated with a coal boom decreased high school enrollment rates.[3] Higher earnings means a higher opportunity cost associated with attending school, so individuals have a greater likelihood of choosing work over school.

The work of Black et al. is closely related to the literature on the *resource curse*, i.e., the notion that a greater dependence on natural resources results in slower economic growth.[4] An expansive literature debates this phenomenon and provides several possible explanations. One explanation which is particularly relevant to this paper is that a resource-rich area may not feel as great of a need to invest in elementary and secondary education because of labor market opportunities tied to the local natural resource base. The implication is that the resource curse leads to lower levels of school funding than would otherwise be the case. A closely related explanation is that attractive local job opportunities in resource rich communities may diminish enrollment rates and educational attainment. Another explanation for slower economic growth is that relatively high wages in the resource industry may crowd out growth in other industries like manufacturing (a phenomenon often referred to as "Dutch Disease"). This may be especially important in coal communities where the available labor pool is small and there is a strong union presence.

Several studies have examined the impact of coal mining on economic growth, including growth in the Appalachian region.[5] This is an important question since overall economic growth will be influenced by the education and skill levels of local residents. In support of the resource curse thesis, the presence of coal in the Appalachian region has been found to negatively impact income growth (Douglas and Walker, 2017) and be negatively associated with entrepreneurship (Betz et al., 2015). On the other

[3] In related work but at the country level, Cockx and Francken (2016) find a negative relationship between a country's natural resource dependence and national expenditures on public education, relative to GDP.
[4] Much of the literature that examines the resource curse uses international data. For example, see Gylfason (2001) and van der Ploeg (2011) for literature reviews and discussions of the resource curse at the country level. For literature reviews of studies examining the impact of natural resources on local labor markets and outcomes, see Marchand and Weber (2017) and Cust and Poelhekke (2015).
[5] Examples of studies that have examined the impact of other natural resources in the U.S. (e.g., oil and gas booms) on employment, wages, income, and welfare include Allcott and Keniston (2017), Hausman and Kellogg (2015), Jacobsen and Parker (2016), Komarek (2016), and Paredes et al. (2015).

hand, Black et al. (2005a) finds coal booms in the Appalachian region had modest, positive spillover effects to employment in the construction, retail and services sectors, but no significant impact on the manufacturing sector. Matheis (2016) finds coal production had a positive impact on the manufacturing sector in the short-run but a negative impact in the long-run, implying the resource curse may be a long-run phenomenon.[6] It is not clear how education funding and attainment levels have affected these findings.

The research presented here is the first to our knowledge that has examined how coal mining activity impacts locally-chosen revenues for public education. This is one avenue through which coal dependence could potentially impact human capital development and thus economic growth. Concentrating on the Appalachian region is particularly important given that the region has lower educational attainment rates, lower incomes, and higher poverty rates, compared to U.S. averages, and many areas within Appalachia have seen steep declines in coal activity. Our results indicate that increases in coal activity in Appalachian counties are generally associated with increases in local revenue per student. These findings are robust and stable across different specifications and samples. An important implication is that declining coal employment will likely translate into a diminished local contribution in support of elementary and secondary education.

Empirical Framework

To examine the impact of coal activity on locally-generated revenues per student in Appalachia, we use a fixed effects regression model and data spanning from 1995 to 2016. Regression analysis allows us to examine the relationship between coal activity and local education funding, controlling for a variety of factors that affect local funding, including federal and state education aid. Multiple measures of coal activity are used including coal employment, coal employment as a share of total employment, coal production, and the number of coal mines with positive production within a county.

In the discussion that follows, we describe the empirical model, data and methodology in more detail. Descriptive statistics for local revenue per student, various measures of coal activity, and control variables for Appalachian coal and non-coal counties are then presented. Section V discusses results from the regression analysis, and Sections VI and VII demonstrates the robustness of results to other

[6] Other studies have examined the impact of coal activity on welfare expenditures, disability program participation, and poverty rates (Black et al., 2002, 2003; Deaton and Niman, 2012)

specifications and discusses endogeneity concerns. Lastly, the paper concludes with a discussion and brief conclusion in Section VII.

Our model of local school funding determination assumes an underlying stylized median voter model that governs the choice of tax rates and thus the level of school funding support at the local level.[7] The median voter is viewed as the pivotal voter in school-based referenda as well as in the election of individuals to local governing bodies that approve school budgets. As such, local school funding outcomes reflect the preferences and tastes of the median voter given their budget constraint. While preferences for schooling support are assumed to be stable, as is typically the case, the median voter's budget constraint will change over time as the fate of the coal industry waxes or wanes. As a result, funding for schooling will change over time as the coal industry evolves.

Using variation in multiple measures for coal activity across counties and time, we estimate the impact of coal activity on locally-determined revenues for elementary and secondary education, controlling for the presence of both state and federal aid (which affects the budget constraint of the median voter). Specifically, the following fixed effects panel-data regression model is estimated for all counties in the Appalachian Regional Commission service area:

$$Y_{ist} = \beta_0 + \beta_1 Coal_{ist} + X_{ist} + \gamma_i + \gamma_t + \varepsilon_{ist} \quad (1)$$

The dependent variable is local revenue per student for county i in state s in year t. The regression framework will explain how various factors influence this revenue. Local revenues, enrollment, and other education finance data for school districts are from the U.S. Census Bureau, Annual Survey of School System Finances and are aggregated to the county-level for years 1995 to 2016.[8,9] $Coal$ represents various measures of coal activity for counties and is either annual coal employment, coal employment as a share of total employment[10], coal production, or the number of mines (with positive

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[7] The median voter model has long been a staple framework for analyzing the choices made by voters under the institution of democracy. Recent examples include Delaney and Dharmapala (2017), who apply the median voter framework to the determination of state subsidy levels for higher education and Schlaffer (2018) who examines how elderly populations affect local school funding for capital projects.
[8] *Year* represents fall of the academic year. For example, 2016 represents education finance data for the 2016-2017 academic year.
[9] The Annual Survey of School System Finances collects data on the finances of elementary and secondary public school systems. Since 1995, the survey has covered the universe or all public-school systems in the U.S. Prior to 1995, a sample of school systems was surveyed except for years ending in 0, 2, and 7.
[10] Coal employment as a share of total employment is calculated using coal employment from the U.S. Department of Labor, Mine Safety and Health Administration and total, non-farm employment from the U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages.

coal production) depending on the specific regression model. Coal employment and production data are from the U.S. Energy Information Administration and Department of Labor, Mine Safety and Health Administration and are aggregated for mines within a county.[11] County-level controls that vary over time are included in X_{ist}. Specifically, personal income per capita (which proxies for the median voter's income), the unemployment rate, and the poverty rate account for differences in economic conditions across counties and the local capacity to fund schooling from own-source taxes.[12] County demographics include the shares of the population that are white, Hispanic, female, and aged 65 and over, as well as population density.[13] To proxy for the local need for K-12 education, a control is included for the percent of the school-age population (ages 5 to 19). Controls also include total employment less coal employment to account for the economic impacts and tax base associated with the presence of other industries in a county.[14] Lastly, γ_i and γ_t are county and time fixed effects to control for time-invariant differences across counties (e.g., county land area that does not change over time) and general time trends. All monetary variables are converted to inflation-adjusted 2016 dollars. Robust standard errors are clustered at the county level.

Descriptive Statistics

Summary statistics are presented in Table 1 for local revenue per student, various measures of coal activity, and the control variables. Column 1 presents means and standard deviations in parentheses for the primary analytic sample, which is all counties in the service area of the Appalachian Regional Commission. Column 2 presents statistics for *coal counties*, which are Appalachian counties that had positive coal employment at any point between 1995 and 2016. Column 3 provides statistics for *non-coal counties* in the Appalachian region, including counties in non-coal states (e.g., Georgia, New York,

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[11] Specifically, mine-level coal employment data was obtained from the U.S. Department of Labor, Mine Safety and Health Administration, and mine-level coal production data was obtained from the U.S. Energy Information Administration. Both coal employment and production were aggregated to produce county-level data. A mine with zero production and employment is missing from the reported data; therefore, a count of the number of mines represents mines with positive production.

[12] Unemployment rates are from the U.S. Bureau of Labor Statistics. Personal income is from the U.S. Bureau of Economic Analysis. Poverty rates are from the U.S. Census Bureau, Small Area Income and Poverty Estimates (SAIPE) Program. Poverty rates are available for all years between 1995 and 2016 with the exception of 1996 in which only state and national estimates were produced. Linear interpolation was used to fill in poverty rates in 1996 for all counties.

[13] Population estimates by age, sex, race, and origin are from the U.S. Census Bureau's Population Estimates Program.

[14] Total employment (and employment by sector) is available from the U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages Program.

North Carolina, and South Carolina). Column 4 presents summary statistics for *all counties* both in and outside of the Appalachian region for Appalachian states.

The average local revenue per student for Appalachian counties is $3,785 (in 2016 dollars) while average local revenue per student for coal counties is higher at $3,903. Note that coal communities provide greater local revenue per pupil than non-coal communities despite having slightly lower income per capita. Note also that local revenue per student is lower for Appalachian counties than *all* counties in the Appalachian states. Table 1 presents summary statistics for total expenditures and current spending per student (also in 2016 dollars). Current spending accounts for instruction while total expenditures include instructional spending and additional expenditures such as capital costs. It is important to recognize that these *spending* figures account for federal, state and local government education dollars whereas local revenue per pupil comes solely from local tax sources. Both expenditures and spending per pupil are higher for coal counties than for non-coal counties.[15] The per pupil revenue and spending data are both of interest, with the former accounting for the local funding contribution and the latter accounting for all spending that is used to support public schooling.

Several different measures of coal activity are used in examining the impact on local revenues for education. While these measures will generally be correlated with one another, each captures a unique dimension of the local coal sector. First, we examine the impact of the number of coal workers, which directly accounts for the influence of coal jobs and coal worker income on the residential tax base and the property tax, as well as other local taxes. The mean number of coal workers is 132 across Appalachian counties and 354 across coal counties. The maximum number of coal workers over the time period examined is 5,350 workers in Pike County, Kentucky in 1995.

Second, coal activity is described by coal employment as a share of total employment. This measure is intended to capture the coal industry's *share* of local economic activity. On average, coal workers make up just 1.5 percent of a county's workforce in the Appalachian region. Among coal counties, coal employment accounts for a higher average of four percent of total jobs. Coal employment in Knott County, Kentucky in 2001 had the highest coal share of total jobs at 53 percent.

Average annual coal production, which will be closely linked to the industry supply chain, is a third measure for coal activity. Average production exceeded 2.3 million short tons for coal counties. Lastly,

[15] Given that the funding source is indistinguishable for total expenditures and current spending (i.e., whether funding stems from federal, state, or local revenues), the primary outcome of interest is on local revenues per pupil, but we discuss results for expenditures and spending per pupil below.

the number of coal mines with positive production is used to measure coal activity.[16] The presence or absence of mines may have unique effects on the local capacity to fund schooling. Across all Appalachian counties, the average number of mines is almost three while the average number of mines for coal counties is eight.

A rich set of control variables are included in the regression models to account for differences in counties across place and time, including economic conditions, prevailing levels of educational attainment, and demographics. All of these factors may affect the amount of local revenue for elementary and secondary education. The population distribution across specific age groups appears to be similar across coal and non-coal counties. On average, people that are age five to 19 make up 19.7 percent of the population in Appalachian counties, and people age 65 and older make up 15.8 percent of the population. In the regression models, we expect larger shares of the population over 65 to reflect less support for education spending since this group typically does not have school-age children in the home. The percent of the population that is female is consistent across coal and non-coal counties and is 50.7 percent for Appalachian counties. On average, 92 percent of the population is white in Appalachian counties, and 2.1 percent of the population is Hispanic. Larger Hispanic populations may raise schooling costs because of the need for English language and other specialized instructional support. The population density is generally lower in Appalachian counties (119 people per square mile), compared to all counties in Appalachian states (383 people per square mile). A denser school-age population may lead to lower schooling costs by reducing transportation costs and the need for smaller, more remote schools.

The poverty rate is higher in coal counties at an average of 19.2 than non-coal counties where the mean poverty rate is 16.5. On one hand, higher poverty rates increase the need for schooling support. But on the other hand, poverty means less income to support both personal consumption and public services. Income per capita is fairly similar across coal and non-coal counties, with the mean for Appalachian counties at $31,242. Higher income should mean higher levels of support for local school funding since economic capacity is greater. The unemployment rate is slightly higher in coal counties at 7.6 percent while the average rate among non-coal counties is 6.9 percent. Unemployment is a sign of economic distress and should dampen local revenue per pupil. The average level of employment after

[16] The data is not inclusive of all mines and does not fully track mine status. For example, only mines that report positive production are included in the data. Therefore, number of coal mines is approximated by summing the number of mines with positive production within a county.

excluding coal workers is 21,979 jobs for Appalachian counties. While earnings outside of the coal sector frequently lag earnings for coal workers, we nonetheless expect this "other" employment variable to positively influence local schooling revenues.

Table 1: Summary statistics for schooling outcomes of interest, measures of coal activity, and control variables, 1995 to 2016

	(1) Appalachian counties	(2) Appalachian coal counties	(3) Appalachian non-coal counties	(4) Appalachian states, all counties
Local revenue per student	3,784.773	3,903.321	3,714.005	4,231.674
	(2,231.912)	(2,328.780)	(2,169.145)	(2,797.612)
Expenditures per student	11,609.264	12,131.337	11,297.609	11,698.395
	(3,202.831)	(2,876.799)	(3,344.121)	(3,464.631)
Current spending per student	10,152.584	10,594.690	9,888.665	10,225.504
	(2,506.354)	(2,183.344)	(2,645.886)	(2,809.356)
Coal employment	132.459	354.348	0.000	55.351
	(423.291)	(633.056)	0.000	(276.502)
Coal employment as share of total employment	1.502	4.020	0.000	0.642
	(5.216)	(7.918)	0.000	(3.455)
Coal production (short tons)	874,347.819	2,336,992.318	1,210.228	373,042.894
	(3,287,912.689)	(5,050,225.275)	(38,796.109)	(2,149,937.430)
Number of mines with positive production	2.840	7.594	0.002	1.146
	(9.244)	(13.875)	(0.039)	(5.963)
Percent of population age 5 to 19	19.693	19.471	19.826	20.379
	(1.994)	(1.940)	(2.014)	(2.272)
Percent of population age 65 and older	15.790	15.889	15.731	14.738
	(3.212)	(2.783)	(3.441)	(3.391)
Percent female	50.673	50.508	50.771	50.758
	(1.530)	(1.686)	(1.419)	(1.914)
Percent white	91.905	95.202	89.937	80.476
	(11.366)	(7.256)	(12.826)	(19.194)
Percent Hispanic	2.100	1.161	2.660	3.039
	(2.798)	(1.521)	(3.206)	(3.805)
Population density (per square mile)	119.209	114.328	122.124	382.769
	(160.035)	(162.596)	(158.429)	(2,743.085)
Poverty rate	17.534	19.209	16.533	17.015
	(5.861)	(6.907)	(4.869)	(6.721)
Income per capita	31,242.004	30,991.112	31,391.775	33,752.220
	(5,451.576)	(6,055.895)	(5,051.131)	(8,715.718)
Unemployment rate	7.183	7.647	6.907	6.887
	(2.716)	(2.573)	(2.762)	(2.834)
Total employment net coal employment	21,979.145	25,098.200	20,117.200	38,964.944
	(48,301.192)	(64,115.387)	(35,538.675)	(110,172.878)
Observations	9,240	3,454	5,786	23,540

Notes: The table lists the mean of the outcomes of interest, different measures of coal activity, and control variables for years 1995 to 2016. Column 1 represents all counties in the ARC-defined region. Column 2 consists of coal counties in the ARC-defined region (i.e., counties that had positive coal employment at any point between 1995 and 2016). Column 3 lists statistics for non-coal counties in the ARC-defined region, including non-coal counties in non-coal states (Georgia, North Carolina, New York, and South Carolina). Column 4 represents Appalachian states and includes counties in and outside of the ARC-defined region. All dollars are 2016 inflation-adjusted dollars. Standard deviations are in parentheses.

Regression Results

Local Revenue per Student

Equation 1 is estimated for all counties in the Appalachian region to examine the impact of coal activity on local revenues per student. Results are presented in Table 2. When a coefficient is statistically significant, asterisks are included; a positive and statistically significant coefficient means that the variable of interest has a positive impact on local revenues per pupil while the opposite holds for statistically significant negative coefficients.

- Column 1 shows results for when $Coal_{ist}$ is measured by *coal employment* in county i in state s in year t, which spans from 1995 to 2016.
- Column 2 illustrates impacts when $Coal_{ist}$ is measured by *coal employments' share of total employment*.
- Column 3 demonstrates the impact of *coal production* on local revenues per pupil.
- And Column 4 illustrates impacts for when $Coal_{ist}$is represented by the *number of coal mines with positive coal production*.

Results are consistent across the different measures of coal activity with all measures having positive, statistically significant impacts on local revenues per student. The results for control variables are also consistent across the different models. While not all control variables are statistically significant, the results generally show the expected sign. For example, as income per capita increases, local revenues per student increase. As the poverty rate goes up, on the other hand, local revenues per student go down. The coefficients for both of these variables are of a similar order of magnitude across the models. The population density measure has a consistent negative impact on local revenue per pupil. This could reflect economies in the delivery of schooling services to a largely proximate local student population as suggested above. Surprisingly, the share of the population that is school aged has a negative impact on local revenues per pupil. It is possible that the presence of a relatively large share of school-aged children, all else the same, means a smaller share of local workers and thus a narrower base to support locally-provided public services. A larger
Hispanic population translates into higher local revenue. Finally, higher local unemployment rates seem to translate into higher local spending per pupil which is inconsistent with expectations.

Of primary interest in Table 3 are the results for the measures of coal activity. Assuming all other variables in the model are fixed, the results in Column 1 indicate that if coal employment increases by one job, then local revenue per pupil increases by 54 cents, with 95 percent confidence intervals measuring an increase of between 26 and 81 cents. This means that if coal employment increases by 100 workers, then local revenues per pupil will increase by $54, which represents 1.4 percent of the mean of local revenue per pupil for Appalachian counties ($3,785). To help frame this estimate, the average number of coal jobs for a coal county in Appalachia is 354, as shown in Table 1. In sharp contrast, non-coal employment in a county boosts local spending per pupil by just 3 cents for each job, a result that is consistent across the specifications. The greater impact on local revenues for coal jobs versus other jobs likely reflects the relatively higher earnings for coal employment and a robust business base and supply chain for the coal sector. Column 2 shows that a one percent increase in coal employments' *share* of total employment implies a gain of $46 in local revenue per pupil. Recall the average for coal employments' share of total employment for Appalachian counties is 1.5 percent (see Table 1). This result is also much higher than the result for non-coal jobs.

Column 3 shows that if coal production increases by one short ton, then local revenues per student increase by a very small amount (in scientific notation, just 5.1×10^{-5}). An easier interpretation is that if coal production increases by one million short tons, then local revenues per pupil increase by $51, noting that the 95 percent confidence interval is from $19 to $83. For reference, one million short tons is 1.14 times the average, annual production for all Appalachian counties and about half as much as the average, annual production for Appalachian counties that have a coal presence. Lastly, Column 4 demonstrates the impact of the number of mines with positive coal production on local revenues per student and indicates that one additional mine corresponds to an increase of $13 in local revenues per student, with the 95 percent confidence intervals measuring between $5 and $21. Together, these results imply that increases in coal activity, whether the transmission mechanism is coal employment, production, or the number of mines, significantly increases local revenues per student. These impacts appear to be much larger than the impacts from other economic activity within the county. This also means that the loss of coal activity will have a greater negative impact on local school finances than the loss of a job in another sector of the local economy

Table 2: The impact of coal activity on local revenue per student using different measures of coal activity

	(1) Coal Employment	(2) Coal employment as share of total employment	(3) Coal production (short tons)	(4) Number of mines with positive production
Measure for coal activity	0.536***	46.217***	5.1E-05***	12.737***
	(0.139)	(11.066)	(0.000)	(3.989)
Percent of population age 5 to 19	-246.730***	-247.788***	-245.029***	-244.182***
	(46.321)	(45.824)	(46.302)	(46.821)
Percent of population age 65 and older	-26.310	-25.798	-27.694	-28.752
	(32.120)	(32.033)	(32.178)	(32.306)
Percent female	35.212	34.305	31.737	30.181
	(58.139)	(58.220)	(57.964)	(58.257)
Percent white	-43.963	-44.874	-42.115	-41.119
	(32.251)	(32.139)	(32.320)	(32.497)
Percent Hispanic	50.221*	51.744*	50.714*	51.105*
	(27.622)	(27.514)	(27.692)	(27.833)
Population density (per square mile)	-5.145***	-5.078***	-4.869***	-4.905***
	(1.544)	(1.540)	(1.548)	(1.553)
Poverty rate	-22.572**	-22.739**	-24.913**	-24.581**
	(9.828)	(9.804)	(10.006)	(10.049)
Income per capita	0.055***	0.055***	0.058***	0.057***
	(0.016)	(0.016)	(0.016)	(0.016)
Unemployment rate	35.017***	34.499***	33.135***	31.958***
	(9.357)	(9.294)	(9.245)	(9.181)
Total employment net coal employment	0.030***	0.029***	0.028***	0.029***
	(0.007)	(0.007)	(0.007)	(0.007)
Observations	9,240	9,239	9,240	9,240

Notes: The table lists the impact of coal activity on local revenue per student using Equation 1 for different measures of coal activity. Column 1 measures the impact of coal employment on local revenue per student. Column 2 lists estimates for the impact of coal employment as a share of total, non-farm employment on local revenue per student. Column 3 lists results for the effect of coal production on local revenue per student. Column 4 illustrate the impact of the number of mines with positive production on local revenue per student. Robust standard errors, clustered by county, are in parentheses.

*** p<0.01, ** p<0.05, * p<0.10

Increases versus Declines in Coal Activity

In this section, we discuss whether there are differential impacts between when a community is experiencing an increase versus a decrease in coal activity. A declining coal sector will be associated with a declining tax base and may also give rise to community anxiety regarding the ability to fund locally-provided public services. The opposite will be true of places with a growing coal sector, where economic growth and optimism may translate into a greater commitment to funding local schools. To address this question, Equation 1 is estimated as previously described except for the measure of coal activity ($Coal_{ist}$). In one regression coal activity is the *annual change in coal employment when the change is positive* (i.e., coal employment increased from the previous year) and zero otherwise. And in a second regression, coal activity is the *annual change in coal employment when the change is negative* (i.e., coal employment decreased from the previous year) and zero otherwise. These two measures allow us to examine whether there is symmetry or asymmetry associated with the local funding commitment to elementary and secondary education. We limit regressions to coal counties in Appalachia in order to compare coal counties with a positive change in employment to other coal counties where employment is either zero or the change is negative (and vice versa).

While we do not report the detailed findings here, we do arrive at asymmetric results for these two specifications. On one hand, the results suggest a positive, albeit weakly statistically significant impact of a positive change in annual coal employment on local revenues per student. This finding is consistent with the baseline results reported in Table 2. On the other hand, a negative change in coal employment registers as statistically insignificant for changes in local revenues per student. This suggests that increases in coal employment have a significant positive impact on local revenues while declines in coal employment have no impact. While this offers some encouragement regarding sustained spending support in communities witnessing a declining coal sector, several caveats apply. First, *ongoing* declines in coal employment, as opposed to simply *annual* declines, will ultimately have implications for the local economic base and tax base, so sustained spending in the face of declining coal activity seems unrealistic, especially in the long run. The model presented in this section suggests that changes in local revenues take place slowly. Second, the results are not as robust as the models presented above, with both positive and negative employment changes frequently being insignificant in different model specifications. Finally, our core findings, reported in Table 2, reveal stable and consistent impacts of various measures of coal activity on local revenues per pupil. These findings suggest that a declining coal sector would ultimately have negative impacts on local education funding, whether measured by employment, production or the number of mines. The models also suggest that the replacement of coal jobs with jobs in other sectors of the local economy will produce lower levels of local revenue per pupil.

Spending per Student

In addition to examining the impact of coal activity on local revenue per student, we also examine the impact of coal activity on spending per student. These complementary regression models of school spending capture the impact of federal, state and local dollars and thus measure the amount of resources from all sources flowing in support of elementary and secondary education at the local level. Specifically, Equation 1 was estimated using *total expenditures* per student and *total current spending* per student as outcomes, with a notable difference being that total current spending includes instruction while total expenditures includes instruction and other spending such as capital costs. While we do not report the coefficient estimates here, for both outcomes, results were generally similar to those using local revenues per student. An additional coal worker significantly increased total expenditures per student and total current spending per student by 40 and 45 cents, respectively. Coal employment as a share of total employment in a county increased total expenditures and total current spending by $62 and $44, respectively. Coal production did not significantly impact total expenditures per student, but coal production did positively impact current spending per student, in similar magnitude to results for local revenue per student. The impact of the number of coal mines with positive production was comparable as total expenditures and current spending increased by $15 and $21, respectively.[17] These results imply that coal activity impacts spending in addition to local revenue per student.

Specification and Robustness Checks

In Table 3, we assess whether the results for the measures of coal activity on local revenue per pupil are sensitive to other specifications and samples of counties. In doing so, we only report the coefficients for the coal variables that were included in Table 2 in order to focus on the alternative specifications of the various models. Similar to Table 2, Columns 1 through 4 show results from estimating Equation 1 and using the different measures of coal activity (e.g., coal employment, coal employment as a share of total employment, coal production, and number of mines). In order to facilitate comparisons, Row A of Table 3 shows the baseline estimates of the impact of the four coal activity measures on local revenue per student and are identical to those presented in Table 2. Rows B through I also show estimates for the impact of coal activity on local revenue per student, but each row differs from the baseline specification as described below. To emphasize, our interest is the degree to which the coefficients on the four coal variables change under different model specifications. Fortunately, the results show that the findings are in fact stable and robust.

[17] The impact of coal activity on effort was also separately examined where effort is the ratio of local revenue per pupil to total personal income (the latter serving as a measure of local tax capacity). For brevity, these results are excluded, but as coal activity increases, effort significantly increases. This result was consistent across different measures for coal activity (e.g., coal employment, coal employment as a share of total employment, coal production, and number of mines) and specifications.

Row B includes two key additional controls to the baseline specification, aid from federal and state sources. Row C adds a control for manufacturing employment, and redefines the non-coal employment variable to be total employment minus *both* manufacturing and coal employment. Row D uses state-by-year fixed effects instead of time fixed effects to account for policies that may be implemented over time at the state level. Rows E through I show results from estimating baseline Equation 1, but a different sample is used in each row. Row E is estimated for Appalachian coal counties only (i.e., Appalachian counties that had positive coal employment at any point between 1995 and 2016). Row F shows results for the top 20 coal counties according to coal employment as a share of total employment. Rows G and H illustrate impacts for Appalachian coal counties where annual coal employment was ever greater than the 75th and 95th percentile, respectively. Lastly, Row I shows results for all counties in Appalachian states including counties in and outside of the region defined by the Appalachian Regional Commission.

Table 3 shows that the estimated impact of coal activity on local revenue per student is very robust and generally consistent in terms of magnitude and significance across the various specifications, which either add additional controls, use state-by-year fixed effects, or are estimated for different samples. Increasing coal employment results in increases in local revenue per student with the exception of two specifications. Results are weaker (i.e., significant at the 10 percent instead of 1 percent significance level) when only including counties where coal employment surpasses the 75th percentile. The coefficient on coal employment also turns insignificant when estimations only include counties where coal employment surpasses the 90th percentile. However, when estimations only include the top 20 Appalachian coal counties according to coal employment as a share of total employment, the impact of coal employment remains significant at the 1 percent significance level. In this instance, the coefficient is larger in magnitude than the baseline model, as an additional coal worker corresponds to an increase of 89 cents rather than 54 cents in local revenues per student.

Likewise, results remain significant and positive for other measures of coal activity including coal employment as a share of total employment, coal production, and the number of mines with positive production apart from similar exceptions (i.e., weaker or insignificant results when only including counties with coal employment in the top 25th or 10th percentile). Together, Table 3 demonstrates the robustness of results across different specifications and that coal activity is associated with significant increases in local revenue per student.

Table 3: Specification checks: The impact of coal activity on local revenue per student

	(1)	(2)	(3)	(4)
	Coal Employment	Coal employment as share of total employment	Coal production (short tons)	Number of mines with positive production
A. Baseline estimates	0.536***	46.217***	5.1E-05***	12.737***
	(0.139)	(11.066)	(0.000)	(3.989)
B. Including federal and state aid	0.534***	45.604***	5.0E-05***	12.417***
	(0.142)	(11.391)	(0.000)	(4.065)
C. Including manufacturing employment	0.535***	46.134***	5.1E-05***	12.683***
	(0.139)	(11.075)	(0.000)	(3.983)
D. State-by-year fixed effects	0.480***	39.976***	4.7E-05***	12.239***
	(0.159)	(12.473)	(0.000)	(4.711)
E. Appalachian coal counties only	0.490***	41.997***	5.2E-05***	13.048***
	(0.163)	(12.038)	(0.000)	(4.384)
F. Top 20 coal counties	0.898**	49.168**	1.2E-04**	31.695
	(0.386)	(23.312)	(0.000)	(21.485)
G. Coal employment greater than 75th percentile	0.462*	34.552**	4.5E-05*	7.956
	(0.236)	(16.040)	(0.000)	(6.264)
H. Coal employment greater than 90th percentile	0.502	36.332	5.7E-05	9.885
	(0.358)	(31.170)	(0.000)	(12.516)
I. Appalachian states, all counties	0.465***	41.021***	4.6E-05***	11.924***
	(0.128)	(10.051)	(0.000)	(3.638)

Notes: The table lists specification checks for the impact of coal activity on local revenue per student using Equation 1. Column 1 lists results for the impact of coal employment. Column 2 illustrates the impact of coal employment as a share of total, non-farm employment. Column 3 lists the estimates for the effect of coal production. Column 4 illustrates the impact of the number of mines with positive production. Row A lists the baseline estimates, which are identical to those presented in Table 2. Rows B through I also estimate the impact of coal activity on local revenue per student, but each row differs from the baseline specification in one respect. Row B includes federal and state aid as additional control variables. Row C includes manufacturing employment and total employment net manufacturing and coal employment. Row D uses state-by-year fixed effects rather than time fixed effects. Row E through I use the same specification as the baseline but illustrate results for different samples. Row E shows results for Appalachian coal counties (i.e., counties that had positive coal employment at any point between 1995 and 2016). Row F shows results for the top 20 coal counties according coal employment as a share of total, non-farm employment in 2016. Row G and H list results for Appalachian coal counties where coal employment was ever greater than the 75th and 90th percentile, respectively. Row I illustrates results for Appalachian states including all counties in and outside of the ARC-defined region. Robust standard errors, clustered by county, are in parentheses.
*** p<0.01, ** p<0.05, * p<0.10

Endogeneity Concerns

The empirical models presented here are intended to show the way in which coal activity affects local school funding. The interpretation is that coal activity is the causal force that is identified in the regression models. However, one statistical concern is that counties may differ in unobserved characteristics over time that affect economic and fiscal conditions, and these characteristics are in turn correlated with both historical and current intensity of coal mining and the emphasis placed on education. For example, successful coal communities may benefit from some form of transportation comparative advantage that not only helps foster growth in the coal industry but also benefits other components of the local economic base and tax base. If this is in fact the case, then the relationship between coal activity and school funding is spurious rather than causal.

Following Metcalf and Wang (2019) and in the spirit of a Bartik-style identification approach, we develop an instrumental variable for coal activity to address endogeneity concerns. Specifically, we predict coal employment growth for counties using county coal employment in the base year (i.e., 1995) and the *national* growth rate in coal employment, with the idea being that *national* coal employment is exogeneous to local revenues per pupil (i.e., national employment is determined by factors outside the local coal community). We estimate the same fixed effect model as described in Equation 1, but use the aforementioned instrumental variable to predict county-level coal employment. Encouragingly, results are consistent with the baseline results in terms of both coefficient magnitude and level of significance. Increases in coal activity result in increases in local revenue per pupil. Specifically, an additional worker corresponds to an increase of 59 cents (rather than 54 cents as found in the baseline specification) in local revenue per pupil.

Conclusion

This is a second part of a two-part research project on the coal industry and funding for primary and secondary education in the Appalachian region. The first part provided a detailed descriptive analysis while this paper examines the impact of coal activity on local revenues per student by using a fixed effects panel data regression model. Using education finance data from 1995 to 2016 and multiple measures of coal activity—coal employment, coal employment as a share of total employment, coal production and the number of coal mines—we find that increases in coal activity lead to increases in local revenue per student. The results are generally consistent with expectations and robust across a wide array of models.

The evidence shows the importance of coal activity to local communities in terms of their ability to invest resources in their future through current-period support for elementary and secondary education. A growing coal sector means a stronger economic and fiscal base and thus stronger local support for public school funding: the community chooses to take advantage of economic prosperity by plowing additional revenues into the local school system. The estimates indicate that when coal employment in a county increases by 100, there is a $54 dollar increase in local revenue per pupil. Similarly, if county coal production rises by 1 million short tons, this yields a $51 per student increase in local funding for the public schools.

The evidence also suggests that places with a declining coal sector will place fewer dollars into public school coffers. Even if new jobs are created that replace coal jobs in the community, the evidence presented her suggests that the amount of support for local schooling will be diminished. Unfortunately, this raises the risk of investing too little into the workforce of the future, in turn compromising future growth and prosperity. One way to address this is to ensure that state education aid programs are sensitive to local economic conditions and the presence of economic stress. State revenues can help plug the fiscal hole created by declining local tax capacity.

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