Coal Mining and Regional Economic Development in Pennsylvania, 1810-1980

by

David A. Latzko

Business and Economics Division
Pennsylvania State University, York Campus

1031 Edgecomb Avenue
York, PA 17403

phone: 717-771-4115
fax: 717-771-4062
e-mail: dlatzko@psu.edu

Coal Mining and Regional Economic Development in Pennsylvania, 1810-1980

Abstract

Coal mining did not curse the long run development of Pennsylvania's anthracite and bituminous regions. From 1850 to 1950, mining positively impacted the economies of the state's coal counties, especially the bituminous-producing counties. As manufacturing production became more energy-intensive around the turn of the century, proximity to cheap coal became an important cost consideration. Fuel-intensive industries like steel concentrated near the western Pennsylvania bituminous coal fields. With the declining importance to manufacturing of energy inputs in general and coal in particular after 1920, the economies of Pennsylvania's coal counties gradually came to look no different than the state's non-coal counties.

JEL codes: N9, O4, R1

keywords: regional history, regional economic development, coal mining

Coal Mining and Regional Economic Development in Pennsylvania, 1810-1980

The first record of a coal mine in Pennsylvania on a map is on one of Fort Pitt dated 1761 (Eavenson 1942, p. 8). Anthracite coal is known to have been used by Obadiah Gore in 1769 at his Wilkes-Barre blacksmith shop (Powell 1980, p. 4). A load of coal was shipped down the Susquehanna River in 1776 for use at the armory in Carlisle, a trade that continued for the duration of the Revolutionary War (Healey 2007, p. 48). Commercial production of anthracite coal really began in 1807 when Abijah and John Smith loaded 50 tons on an ark and floated it down the Susquehanna River on an October freshet to Columbia (Eavenson, 1942, p. 143). Bituminous coal was also first mined for local consumption, but there are reports of it moved by boat down the Monongahela River as early as 1789 and on the Ohio River in 1793 (Hoffman 1978, p. 354).

Through the first few decades of the 19th century, the use of coal was restricted to the blacksmith's forge, the occasional blast furnace, steam engines, home heating, and the glass and salt industries (DiCiccio 1996, p. 4). Limited demand and a sparse transportation system restrained the expansion of both the anthracite and bituminous coal industries. In 1810, 350 tons of anthracite and 120,700 tons of bituminous coal were mined in Pennsylvania (Commonwealth of Pennsylvania 1892, p. 84; Pennsylvania Department of Mines 1955, p. 58). The opening of the Schuykill Navigation, Lehigh, Delaware and Hudson, Delaware Division, and Morris canals between 1825 and 1832 provided an outlet for anthracite coal to reach the Philadelphia and New York markets (Jones 1908). Pennsylvania's Main Line canal was useful as an outlet to the east for bituminous coal mined on the eastern slopes of the Allegheny Mountains but of very little value to the area around Pittsburgh. When the canal to Erie was completed in 1834 and connections made with the Ohio canals in 1838, a considerable amount of bituminous coal was moved on them from around Pittsburgh and areas further north (Eavenson 1942, p. 186).

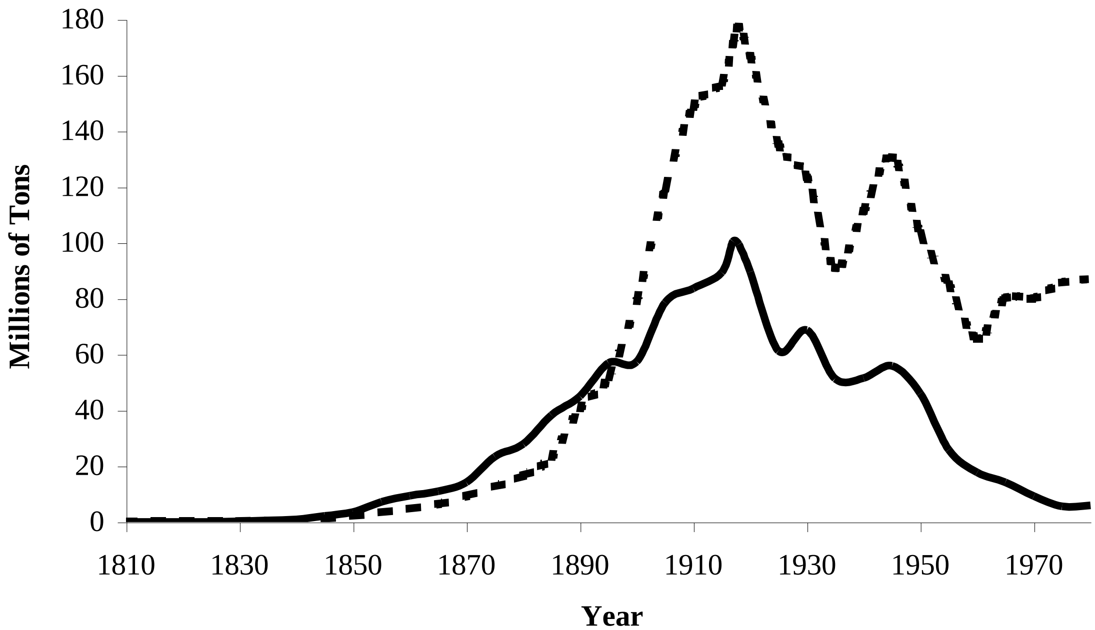

Figure 1. Annual Production of Anthracite (solid line) and Bituminous (dashed line) Coal in Pennsylvania.

With the opening of the canals and the development of commercial coal markets, both the anthracite and bituminous industries in Pennsylvania began a rapid expansion. Anthracite and bituminous production were 1,129,206 and 699,994 tons in 1840 (DiCiccio 1996, p. 59). The development of Pennsylvania's mining industries is evident in Figure 1. Coal production in Pennsylvania reached a peak during World War I, with 100,445,299 tons of anthracite mined in 1917 and 177, 217,294 tons of bituminous coal produced in 1918 (Pennsylvania Department of Environmental Resources 1980, p. 31 and 85). Coal's decline was as rapid as its rise. By 1980, anthracite production in Pennsylvania amounted to just 5,983,149 tons while bituminous production was 87,068,738 tons (Pennsylvania Department of Environmental Resources 1980, p. 31 and 85).

What has been the long run impact of this mining on the economies of Pennsylvania's coal regions? The economic development literature tells of "the curse of natural resources" (Sachs and Warner 2001): countries with an abundance of natural resources experience slower economic growth than resource poor countries. The negative correlation between economic growth and resource abundance is often attributed to some form of crowding out. Extensive development of natural resources may harm manufacturing industries by causing the currency to appreciate (Gylfason, Herbertsson, and Zoega 1999) or by driving up the prices of non-traded inputs (Sachs and Warner 1999) or by reducing the incentives to engage in entrepreneurial activity in manufacturing (Sachs and Warner 2001) or to accumulate human capital (Papyrakis and Gerlogh 2007) or by encouraging corruption and rent-seeking (Robinson, Torvick, and Verdier 2006). Thinking about Pennsylvania's coal regions, coal mining, by increasing the demand for labor, may raise local wages for manufacturing workers, reducing the competitiveness of local manufacturers. Or, perhaps, the coal barons actively sought to prevent industrialization of the coal regions: "(t)he great coal and transportation companies . . . policy of excluding outside industry from the region through their control of local officials and chambers of commerce paid off for them in a captive labor market . . ." (Miller and Sharpless 1985, p. 321). Although local interests did attempt to attract outside industry during coal's heyday (Aurand 1970), stories still circulate that Ford Motor Company or RCA or some other major company had wanted to build a plant in the anthracite region (the details depend on who is telling the tale) but the coal companies would not let them in (Dublin and Light 2005. p. 133).

On the other hand, an abundance of natural resources is cited as a reason why the United States surpassed Great Britain in the nineteenth century (Habakkuk 1962) while Auty (2001) argues that the underperformance of resource-abundant countries is just a post-1973 phenomenon. Looking at the United States, Mitchener and McLean (2003) find that states with large mineral endowments had higher productivity levels between 1880 and 1980. Mitchell (2006) finds little evidence that oil-abundant counties in the southern United States experienced negative economic outcomes in the period between 1940 and 1990. And, Wright (1990) notes that the most distinctive feature of U.S. manufacturing exports around the turn of the twentieth century was its intensity in nonrenewable natural resources. Wright and Czelusta (2004) maintain that natural resources are not to blame for corruption and rent seeking and that the resource curse is not inevitable. Indeed, one can argue that the combination of ready-access to coal and agglomeration economies may have potentially provided a boost to the long-term prospects of Pennsylvania's coal mining areas. Agglomeration economies are the benefits producers obtain when located near each other (Goldstein and Gronberg 1984). These benefits, a combination of scale economies and network externalities, can come from the supply side of the market (information spillovers, competing suppliers, thicker labor markets, and so on) as well as from the demand side, for example, the home market effect (Helsey and Strange 1990; Rosenthal and Strange 2001). Agglomeration economies push economic activity to become increasingly geographically concentrated. There also are agglomeration diseconomies; congestion, higher input prices, and product price competition encourage economic activity to be dispersed over a geographic area.

Ellison and Glaesser (1999) find that maybe half of agglomerations of individual industries are due to natural cost advantages. Cheap coal would be such an advantage, and coal was less expensive close to the source. In 1860, the price of anthracite coal at the mine was $1.48 a ton; the wholesale price of anthracite averaged $3.40 a ton in Philadelphia and $5.52 a ton in New York (Schaefer 1977, p. 216, 218, and 220). The same was true for bituminous coal, which cost up to $2 more a ton in Cincinnati and Louisville than in Pittsburgh where it cost around $1.50 a ton (Binder 1974, p. 44). So, locating a manufacturing facility in the coal region provided an energy cost advantage. This would be especially important for energy-intensive industries such as brewing, glass making, paper production and iron making, where coal was one-quarter of the cost of production (Chandler 1972, p. 164).

A history of Pennsylvania's coal industry asserted that "(t)he coal industry has been a prime factor in Pennsylvania's amazing economic development, its growth of population, and its wealth" (Billinger 1954, p. i). Cheap power from the proximity of coal may have been technologically essential as manufacturing developed. Low energy costs from inexpensive coal attracted industry. One observer noted concerning Pittsburgh's industrial development that "one obvious fact persists: the raw materials which fed her mills and shops came to the source of cheap fuel (Binder 1974, p. 43-44). These pioneer manufacturers would attract other manufacturers to the region to take advantage of the externalities generated by the presence of other producers. As long as the agglomeration economies were sufficiently strong, coal region economies would experience more rapid economic growth than areas not blessed with abundant coal. The purpose of this paper is to examine whether and how regional economic outcomes in Pennsylvania are correlated with coal mining.

I. Data and Methods

To analyze the effects of coal mining on regional economic development I use county-level data, derived from U.S. Census data, which spans the period 1810 to 1980. Coal mining was an important contributor to regional economies for over a century. Data, then, is needed over a long period of time. Counties are the logical unit of analysis as they are the smallest geographic entities for which a long time series of economic data can be constructed. Beginning with 1810, the decennial U.S. censuses contain tabulations by county of various economic variables. Later, periodic economic censuses provide county-level data.

County-level data is also appealing for the theoretical reason suggested by Beeson, DeJong, and Troesken (2001, p. 671): "county borders are attractive because they better reflect the limits of local economies than do the borders of states, regions, or nations, which are aggregates of local economies; or cities, whose political boundaries often exclude a portion of the local economy . . .." City-level data fails to span the entire geographic space while more aggregated data may hide important local variation. One difficulty with using counties as the units of analysis is that the geographic boundaries of many counties have changed over time. New counties were carved out of existing counties. So, the county boundaries extant at the time of each decennial census, taken from Thorndike and Dollarhide (1987) are used.

In order to focus the analysis on the influence of coal mining on economic outcomes over a long time span, I want to examine counties that are similar in terms of economic institutions and opportunities other than the existence of coal mining. Adams (2004) compares the development of the coal industry in Virginia and Pennsylvania to contrast the ways that each state developed its coal resources. Virginia policy promoted the interests of agriculture while in Pennsylvania it was difficult for a single set of interests to dominate the state legislature as it was proportioned by population and periodically readjusted to reflect changes in the geographical distribution of the state's population. The Pennsylvania political system produced rival interests and competing factions, which produced policies helpful for economic growth and the coal industry. Adams' (2004) study highlights the importance of institutions for the course of economic development. To assure a homogeneous institutional framework, I limit this study to Pennsylvania counties.

Nearly all the anthracite coal mined in the United States came from Pennsylvania. The state also dominated the U.S. bituminous industry, accounting for 42 percent of national production in 1850 and one-third in 1915; Pennsylvania's share of total U.S. bituminous production in 1974 was still 13 percent (Hoffman 1978, p. 358).

There are four anthracite coal fields in Pennsylvania (Hudson Coal Company 1932, p. 12-20): the Northern field in the Wyoming and Lackawanna Valleys extending through Luzerne, Lackawanna, and small portions of Susquehanna and Wayne Counties, the Western Middle field in Northumberland, Columbia, and Schuykill Counties, the Eastern Middle field centered on Luzerne County with extensions in Schuykill, Carbon, and Columbia Counties, and the Southern field which extends through Carbon, Schuykill, Lebanon, and Dauphin Counties. Although the Southern anthracite field extends across the northwest border of Lebanon County, I do not include Lebanon among the anthracite-producing counties. Despite deposits of around 1 billion tons, little Lebanon County coal has been mined (Edmunds 1972, p. 32). Thus, nine Pennsylvania counties are coded as anthracite-producing: Carbon, Columbia, Dauphin, Lackawanna, Luzerne, Northumberland, Schuykill, Susquehanna, and Wayne.

The Main Bituminous field encompasses Allegheny, Armstrong, Beaver, Blair, Butler, Cambria, Cameron, Centre, Clarion, Clearfield, Clinton, Elk, Fayette, Greene, Indiana, Jefferson, Lawrence, McKean, Mercer, Somerset, Venango, Washington, and Westmoreland Counties (DiCiccio 1996, p. 12). Somerset County also contains a portion of the Georges Creek field. The Broad Top field is in Bedford, Fulton, and Huntingdon Counties. The coal mined in Bradford, Lycoming, and Tioga Counties comes from the North-Central fields. Although the coal in Sullivan County is classified as semi-anthracite with

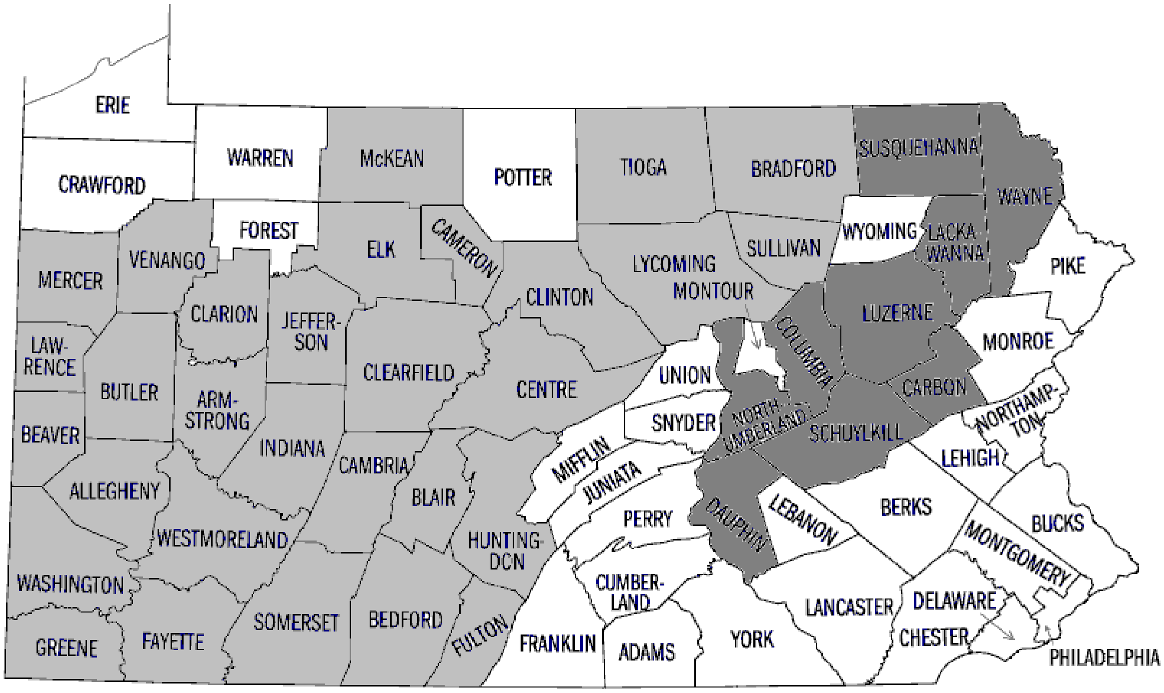

Figure 2. Anthracite (dark shaded) and bituminous (light shaded) coal-producing counties.

a carbon content between bituminous and anthracite, I include Sullivan among the bituminous counties because its coal fields are geographically located among the North-Central bituminous deposits. Small coal reserves in Crawford, Erie, Forest, Warren, and Wyoming Counties are neither workable to a significant extent nor of much value (Edmunds 1972, p. 34; Pennsylvania Department of Mines 1955). Consequently, in addition to the nine anthracite counties, the data set contains 30 bituminous-producing counties and 28 non-coal counties. Figure 2 depicts the location of the coal-producing counties.

Four measures of economic development are constructed for each county: agricultural density, literacy rate, manufacturing density, and population density. All densities are per square mile of county area. Tables 1 and 2 list the metrics used to compute county agricultural and manufacturing densities, most often the value of farm products and the value of products in manufacturing, and the sources of the data for these two variables. The data for 1810 is estimated by aggregating the figures provided in Coxe

Table 1. Agriculture Output Metrics and Sources

Year	Variable	Data Source
1810	aggregate agricultural output	Coxe (1814)
1840	estimated value of agricultural output	1840 Census
1850	value of livestock, animals slaughtered, orchard products, and produce of market gardens	1850 Census
1860	value of livestock, animals slaughtered, orchard products, and produce of market gardens	1860 Census
1870	estimated value of all farm products	1870 Census
1880	estimated value of all farm products	1880 Census
1890	estimated value of all farm products	1890 Census
1900	estimated value of all farm products	1900 Census
1910	total value of all crops	1910 Census
1920	total value of all crops	1920 Census
1930	total value of all crops	1930 Census
1940	total value of all crops	1940 Census
1950	value of farm products sold in 1949	1952 County and City Data Book
1960	value of farms products sold (farms with sales of $2500 or more) in 1959	1962 County and City Data Book
1970	value of farms products sold (farms with sales of $2500 or more) in 1974	1977 County and City Data Book
1980	value of farms products sold (farms with sales of $2500 or more) in 1978	1983 County and City Data Book

Table 2. Manufacturing Output Metrics and Sources

Year	Variable	Data Source
1810	aggregate value in dollars of manufactures	Coxe (1814)
1840	estimated value added in manufacturing	1840 Census
1850	annual value of products in manufacturing	1850 Census
1860	annual value of products in manufacturing	1860 Census
1870	annual value of products in manufacturing	1870 Census
1880	annual value of products in manufacturing	1880 Census
1890	annual value of products in manufacturing	1890 Census
1900	annual value of products in manufacturing	1900 Census
1910	-	-
1920	annual value of products in manufacturing	1920 Census
1930	annual value of products in manufacturing	1930 Census
1940	annual value of products in manufacturing	1940 Census
1950	value added by manufacture in 1947	1956 County and City Data Book
1960	value added by manufacture in 1958	1967 County and City Data Book
1970	value added by manufacture in 1972	1977 County and City Data Book
1980	value added by manufacture in 1977	1983 County and City Data Book

(1814), but these numbers, collected during the 1810 Census, are incomplete and incompatible with the data for later years. No manufacturing or agricultural production data is available for 1820 or 1830. The estimates for 1840 were compiled from the census data using the procedures devised by Seaman (1848, p. 134-135 and 139-142) and applying the corrections suggested by Easterlin (1960, p 209-120), Lindstrom (1978, p. 201), and Tucker (1855, p. 178-179). The agricultural and manufacturing data from 1850 onwards is taken directly from the source listed. No manufacturing data is available for 1910. Literacy rates, which attempt to measure the accumulation of human capital, for 1850 through 1900 were estimated using census micro data (Ruggles et al. 2008) and those for 1910 to 1930 were calculated from reported census data. No literacy data is available for 1890.

Rappaport and Sachs (2003, p. 8) argue that population density captures underlying variations in local productivity and quality of life. Consider an area with a set of attributes such as access to navigable water, temperate weather, and rule of law that increase the productivity of resident firms. Firms' high productivity increases the marginal products of both labor and capital, inducing an inflow of each. In the long run, high productivity implies high population density. Also, consider an area with a set of attributes such as waterfront activities, pleasant weather, and low crime that increase the quality of life of local residents. The high quality of life induces an inflow of labor and, since it is complementary, capital. In the long run, high quality of life implies high population density. Consistent with the idea that people vote with their feet, the intuition is that "population density reveals individuals' preferences over local areas by aggregating the indirect contribution to utility via productivity-driven higher wages with the direct contribution to utility via high quality of life" (Rappaport and Sachs 2003, p. 9). Populations are taken from the decennial federal censuses.

II. Results

The top panel in Table 3 shows the effects of coal mining in 1810 (and 1850 for literacy rate) using the cross-section specification suggested by Michaels (2006):

(1) $Y_c = \alpha A_c + \beta B_c + \varepsilon_c$,

Table 3. Effect of Coal Mining on Economic Development

A. Cross Section of Counties (1810 except 1850 for literacy)

	Agriculture	Literacy	Manufacturing	Population
Anthracite	-0.846	-0.075	-1.473	-0.426
	(1.11)	(1.41)	(1.39)	(0.66)
Bituminous	-2.436***	-0.118**	-2.269***	-1.165*
	(4.88)	(3.32)	(3.27)	(1.86)
Adjusted R-squared	0.36	0.13	0.18	0.04
Observations	41	63	41	42

B. Panel of Counties (1840-1980)

	Agriculture	Literacy	Manufacturing	Population
Anthracite x 1840	-0.000030		0.000109	0.000082
	(0.23)		(0.48)	(0.77)
Anthracite x 1850	-0.000053		0.000304	0.000124
	(0.47)		(1.51)	(1.30)
Anthracite x 1860	0.000023	0.000004	0.000401**	0.000189**
	(0.20)	(0.16)	(2.02)	(2.02)
Anthracite x 1870	-0.000025	-0.000008	0.000321	0.000243***
	(0.23)	(0.30)	(1.63)	(2.61)
Anthracite x 1880	0.000042	-0.000006	0.000096	0.000163*
	(0.40)	(0.24)	(0.51)	(1.82)
Anthracite x 1890	0.000064		0.000182	0.000210**
	(0.60)		(0.97)	(2.36)
Anthracite x 1900	0.000106	0.000019	0.000234	0.000122**
	(1.00)	(0.69)	(1.25)	(2.64)
Anthracite x 1910	0.000070	0.000019		0.000284***
	(0.67)	(0.70)		(3.24)
Anthracite x 1920	0.000128	0.000026	0.000235	0.000292***
	(1.22)	(0.96)	(1.27)	(3.34)
Anthracite x 1930	0.000184*	0.000029	0.000195	0.000270***
	(1.76)	(1.10)	(1.06)	(3.11)

Anthracite x 1940	0.000099		0.000293	0.000239***
	(0.95)		(0.16)	(2.77)
Anthracite x 1950	0.000122		0.000105	0.000159*
	(1.19)		(0.57)	(1.84)
Anthracite x 1960	0.000144		0.000111	0.000066
	(1.40)		(0.61)	(0.77)
Anthracite x 1970	0.000048		0.000057	0.000008
	(0.47)		(0.31)	(0.09)
Bituminous x 1840	0.000069		-0.000059	-0.000115
	(0.79)		(0.38)	(1.58)
Bituminous x 1850	0.000170**		0.000036	-0.000004
	(2.20)		(0.26)	(0.07)
Bituminous x 1860	0.000251***	0.000041**	-0.000094	0.000004
	(3.31)	(2.24)	(0.69)	(0.07)
Bituminous x 1870	0.000146**	0.000046**	0.000025	-0.000002
	(1.96)	(2.48)	(0.19)	(0.04)
Bituminous x 1880	0.000201***	0.000044**	0.000089	0.000067
	(2.72)	(2.40)	(0.67)	(1.10)
Bituminous x 1890	0.000198***		0.000194	0.000103*
	(2.69)		(1.48)	(1.69)
Bituminous x 1900	0.000207***	0.000043**	0.000280**	0.000122**
	(2.83)	(2.38)	(2.15)	(2.02)
Bituminous x 1910	0.000235***	0.000044**		0.000174***
	(3.23)	(2.40)		(2.89)
Bituminous x 1920	0.000220***	0.000047***	0.000274**	0.000190***
	(3.03)	(2.58)	(2.12)	(3.17)
Bituminous x 1930	0.000180**	0.000048***	0.000184	0.000150**
	(2.50)	(2.66)	(1.43)	(2.51)
Bituminous x 1940	0.000176**		0.000125	0.000144**
	(2.46)		(0.98)	(2.43)
Bituminous x 1950	0.000041		0.000165	0.000102*
	(0.57)		(1.30)	(1.72)
Bituminous x 1960	0.000099		0.000168	0.000045
	(1.39)		(1.33)	(0.77)

Bituminous x 1970	-0.000003		0.000082	-0.000012
	(0.04)		(0.65)	(0.20)
Adjusted R-squared	0.90	0.92	0.91	0.93
Observations	982	529	913	985

C. Cross Section of Counties (1980)

	Agriculture	Literacy	Manufacturing	Population
Anthracite	-0.480		-0.124	-0.096
	(1.20)		(0.20)	(0.20)
Bituminous	-0.987***		-0.899**	-0.609*
	(3.54)		(2.16)	(1.84)
Adjusted R-squared	0.14		0.04	0.02
Observations	65		63	67

Notes: Dependent variables are the natural logs of the density of the agricultural sector, the percentage of the county population that can both read and write, the density of the manufacturing sector, and population density. Panel regressions include county fixed effects and time effects. t-statistics are in parentheses. *** indicates significant at the 0.01 level. ** indicates significant at the 0.05 level. * indicates significant at the 0.10 level.

where Y_c is the natural log of the county-level outcome. A_c is a dummy variable with a value of 1 for anthracite coal counties. B_c is a dummy variable with a value of 1 for bituminous coal counties, and ε_c is an error term.

In 1810, both the anthracite and bituminous coal industries were small and undeveloped. Reassuringly for an attempt to uncover the impact of coal mining on economic outcomes, the anthracite counties did not differ much at this time from the non-coal counties in agriculture, literacy, manufacturing, and population density. The bituminous-producing counties, mostly located west of the Alleghenies, were significantly less developed than the rest of the state in 1810, although Cuff's (2006) anthropometric data suggests that western Pennsylvanians enjoyed a higher standard of living prior to the Civil War. This is not surprising as the frontier had moved west out of Pennsylvania only a decade before (Florin 1977, p. 89).

Panel B in Table 2 shows the results from regressions of the form:

(2) $Y_{ct} = \phi_c + \psi_t + \alpha_\tau A_c t + \beta_\tau B_c t + \varepsilon_{ct}$,

where Y_{ct} is the natural log of the economic outcome in county *c* in year *t*, ϕ_c and ψ_t are county fixed effects and year effects, α_τ and β_τ are time varying coefficients on the indicators for anthracite and bituminous coal production, and ε_{ct} is an error term.

Coal mining had a long-lived, positive impact on the economic development of both the anthracite and bituminous regions of Pennsylvania. Mining is associated with a higher population density, a proxy for the standard of living, from 1860 to 1950 among the anthracite counties and from 1890 to 1950 in the bituminous areas. While agricultural production and literacy rates in the anthracite region were not significantly affected by mining, farming and human capital accumulation in the bituminous region benefited mightily from mining. Taking county and time effects into account, in 1910 agricultural output per square mile was 56 percent higher and the literacy rate was 3 percentage points higher in a typical bituminous county.

Coal mining did not crowd out manufacturing. At times there was a positive relationship between coal production and manufacturing, but mining is mostly unrelated to manufacturing output. Anthracite mining did have a positive impact early on. In 1860, the manufacturing density of a typical anthracite-producing county was twice that of a similar non-coal county. Mining had its strongest impact on manufacturing in the bituminous region between 1900 and 1920. The manufacturing density of a bituminous-producing county was 70 greater than in an identical non-coal county in 1900.

Panel C in Table 3 shows the effects of coal mining in 1980 using the cross-section specification in equation 1. By 1980, anthracite-producing counties were not experiencing significantly different economic outcomes than non-coal producing counties. The bituminous coal counties were, however, less developed than other counties in Pennsylvania in 1980. Population, manufacturing, and agricultural densities were all lower in these counties. The manufacturing density in a bituminous-producing county was 60 percent lower than in an otherwise similar county.

III. Discussion

The timing of the positive correlation between anthracite mining and manufacturing density in 1860 coincides with the rise of the anthracite iron industry. In 1850, there were 291 blast furnaces in Pennsylvania, 57 of which used anthracite coal as a fuel (Convention of Iron Masters 1850). By 1858, while blast furnaces in western Pennsylvania were still mostly burning charcoal those in eastern Pennsylvania primarily burned anthracite coal (Knowles and Healey 2006, p. 613). There were 93 anthracite blast furnaces in Pennsylvania in 1858; 23 were located in anthracite-producing counties (Lesley 1859). Lesley (1859) lists two anthracite furnaces in Carbon County, five in Columbia County, six each in Dauphin and Luzerne Counties, and two each in Northumberland and Schuylkill Counties. There also were 10 rolling mills located in the anthracite region, one of which (located in Luzerne County) produced 11,338 T-rails in 1856 (Lesley 1859, p. 236). The mines also provided a source of demand as producing iron equipment for mining sustained several anthracite region iron makers (Powell 1980, p. 17-18).

However, the correlation between anthracite mining and manufacturing output was fleeting. Anthracite iron furnaces were not concentrated in the coal fields but in the middle and lower Lehigh, Schuylkill, and Susquehanna River courses because raw material consumption was weighted heavily in favor of ore rather than coal. Warren (1973, p. 19) argues that the lower river valleys of these rivers were attractive to iron makers because there were deposits of iron ore (the ore resources of the anthracite fields were small and high in silica), established charcoal iron works, and established markets (local mills and foundries and in Philadelphia).

Improved rail access to the anthracite region lowered the relative price of coal in distant markets thereby reducing the advantage of being located near the mines. While the Philadelphia and Reading Railroad had completed its line from Pottsville in the Southern anthracite field to Philadelphia in 1842, rail connections from the other anthracite fields were built in the 1850's and 1860's. The Delaware, Lackawanna, and Western Railroad completed a line from Scranton north to a connection with the New York and Erie Railroad in 1851 and a line from Scranton to the Delaware Water Gap in 1856 (Bogen

1927, p. 81 and 83). The Lehigh Valley Railroad opened a line from Mauch Chunk in the Middle coal field to Easton in 1855 and extended the line to Wilkes-Barre in the Northern field in 1867 and to Waverly, New York and an interchange with the Erie Railroad in 1869 (Bogen 1927, p. 112, 117, and 118). In 1871, the Central Railroad in New Jersey through the lease of the Lehigh and Susquehanna Railroad created a line from Wilkes-Barre through the two northern coal fields to Jersey City (Bogen 1927, p. 158). The Delaware and Hudson Company finished a rail line from Carbondale in the Northern field to the Erie Railroad's main line at Lanesboro, Pennsylvania in 1870 and during the succeeding decade built up a railroad system reaching to the Canadian border (Bogen 1927, p. 189). The effect of these rail connections was to drive down the price of anthracite coal in Philadelphia and New York relative to the price of coal at the mine. In 1840, the wholesale price of anthracite coal in Philadelphia relative to the mine price was 3.6; by 1865 the ratio was 1.3 (Schaefer 1977, p. 216, 219, and 220). Similarly, in New York the relative price fell from 5.3 in 1840 to 2.1 in 1863 (Schaefer 1977, p. 218-220).

Also, the dominance of anthracite coal as a blast furnace fuel was short lived. Between 1855 and 1870, anthracite smelted more than half of the iron produced in the United States (Powell 1980, p. 20). But, in 1880, that share was down to 30 percent and by the turn of the twentieth century, less than 1 percent of pig iron production was fueled by anthracite (Warren 1973, p. 110). Cost considerations contributed to the abandonment of anthracite coal by the iron industry in favor of bituminous coke. The demand for anthracite as a domestic fuel kept its price fairly constant while "the feverish competition in opening (bituminous) coal lands and marketing their product have caused an almost uninterrupted fall in its price" (Taussig 1900, p. 147). In addition to the cost disadvantage, anthracite furnaces were also less productive compared to those using coke because anthracite was not suitable for hard driving (Warren 2008, p. 11), a method of increasing the output of a furnace by blowing hot air through it at high pressure.

Anthracite mining had little long run impact on the manufacturing sectors of anthracite-abundant counties and no significant effects on agriculture or the accumulation of human capital in those counties. But, taking population density as being positively correlated with the standard of living, mining had a positive effect on the economies of Pennsylvania's anthracite region between 1860 and 1950. The

1950's, punctuated by the Knox Mine Disaster in 1959 (Spohrer 1984; Wolensky et al. 1999) which led directly to the closing of at least six deep mines and the loss of more than 1,000 jobs in the Northern field, were a period of rapid decline in the anthracite industry. Production fell from 46 million net tons in 1950 to 18 million net tons in 1960; employment collapsed from 75,231 in 1950 to 20,269 in 1960 and then to 6,286 ten years later (Commonwealth of Pennsylvania 1974, p. 68).

The economic development of the bituminous coal counties was more closely tied to mining than the development of the anthracite coal region. The bituminous counties, unsurprisingly as these were among the last counties in Pennsylvania to be settled, initially lagged the rest of the state on all four economic development metrics. Consistent with Sachs and Warner's (2001, p. 833) hypothesis that positive wealth shocks from the natural resource sector create an excess demand for non-traded goods, coal mining encouraged the agricultural development of the bituminous region. Bituminous coal mining was positively associated with agricultural density from 1850 until 1940. Also, the accumulation of human capital, represented by the literacy rate, proceeded faster in the bituminous coal counties between 1860 and 1930, the final year analyzed for that variable.

Technological advances in the transportation and processing of agricultural output over the second half of the nineteenth century meant that food no longer had to be locally grown. As new methods of food processing, distribution, and storage were developed, marginal lands were taken out of cultivation, leaving agricultural production increasingly concentrated on the most productive farmland. In Pennsylvania the land in farms fell from 19,371,015 acres in 1900 to 14,112,841 acres in 1950, close to the acreage a century earlier (Chen and Pasto 1955, p. 8). "The primary cause of this shrinkage was the abandonment of rough or infertile land" (Fletcher 1955, p. 2).

Railroad construction was most rapid between 1850 and 1875. Rail transportation was available during all seasons, which was not true of wagon or water transportation. Manufacturers and farmers had a year-round market. Another advantage of railroads for farmers was their time-saving. Perishable products such as milk, fruit, and vegetables could be marketed greater distances. The first shipment of meat in refrigerated cars was in 1869, and a refrigerated car for transporting fruit was introduced in 1887

(Fletcher 1955, p. 237 and 279). Now, agricultural products could be shipped long distances. Southern and Pacific coast produce became available in Pennsylvania markets, for example, beginning about 1885 (Fletcher 1955, p. 309).

Commercial canning began about 1890 and the quick freezing of vegetables started in 1931. These developments enabled agricultural products to be transported and stored throughout the year. The advent of good roads and motor vehicles in the early twentieth century permitted farmers to bring their products to market themselves.

Over time, because of these improvements in food processing and distribution, agricultural production concentrated in regions with the most productive farmland and land in the coal regions was not especially fertile. Fletcher (1955, p. 24) describes the "blighting effect of coal mining on farming" due to the land sinking or caving in above deep coal workings and the utter uselessness for agriculture of land where strip mining was practiced. Coal mining polluted streams and the sulfuric acid gas fumes from coke ovens killed all vegetation within an average distance of half a mile. Consequently, numerous farms were abandoned in the coal region early in the twentieth century. A survey of farms in Blair County found that one-fourth of the land in farms in 1900 was no longer farmed in 1940 (Fletcher 1955, p. 5).

In Pennsylvania, gross farm production increased in the central and southeastern regions of the state between 1899 and 1949 but decreased in the coal mining western and northern areas of the state (Chen 1954, p. 410). The acreage of land in farms decreased 21 percent in the non-coal counties, 22 percent in the anthracite region, and 27 percent in the bituminous coal counties during the first half of the twentieth century (Chen and Pasto 1955, p. 42).

By 1950, bituminous coal production was no longer statistically associated with agricultural production. The introduction of refrigerated rail cars, the building of good roads and the development of motor transportation, and the rise of commercial canning took the less productive farmland in Pennsylvania out of cultivation. Production per acre of cropland in constant prices went from \$15 in 1899 to \$23 in 1949 (Chen and Pasto 1954, p. 26). This increase in agricultural productivity was most rapid in the southeast portion of Pennsylvania and the slowest in the western bituminous-producing region, leaving gross farm production per farm worker highest in the southeastern counties and lowest in the bituminous coal counties (Chen 1954, p. 411). Crop production per acre was 68 percent higher in southeastern Pennsylvania in 1949 than in the western region of the state (Chen and Pasto 1954, p. 37).

Just as in the anthracite region, mining had a fleeting statistically-detectable impact on the manufacturing sectors of bituminous coal counties. Bituminous mining had a positive association with manufacturing production between 1900 and 1920. This development was partially tied to the use of bituminous coke as a fuel by the steel industry. Western Pennsylvania iron makers were slow to adopt mineral fuels (Knowles and Healey 2006), but by 1880, 40 percent of pig iron was produced using bituminous coke (Warren 1973, p. 110). The dominance of bituminous coke came quickly. In 1890, 71 percent of pig iron production was smelted with bituminous coke (Warren 1973, p. 110). In 1900, that percentage was 85 percent and, in 1905, 90 percent of pig iron was produced using bituminous coke (Warren 1973, p. 110). By the early 1900's, western Pennsylvania industry was the steel industry. In 1905, the value of all Pittsburgh manufactures was $164.4 million; $89.4 million of that was the output of its iron and steel industry (Warren 1973, p. 120).

An anonymous (1889, p. 409) commenter predicted that "(t)he history of iron-making leads us to expect that here, as in other countries, the ore will move to the fuel, and not the fuel to the ore." This was true for other industries as well. The early manufacturing establishments in western Pennsylvania, breweries, glassworks, foundries, and machine shops used bituminous coal as their principal fuel and were located near easily accessible supplies (Binder 1974, p. 42).

Access to bituminous coal was critical for economic development at the turn of the twentieth century. In 1900, 56.6 percent of aggregate energy consumption in the United States was supplied by bituminous coal; in 1910, the percentage was 64.3 and in 1920, 62.3, with nearly two-thirds of the coal used for industrial purposes (Schurr and Netschert 1960, p. 36 and 76). From 1900 to 1920, the period when bituminous coal mining is positively and significantly correlated with manufacturing production, the U.S. showed a rising trend of energy consumption relative to output. Using 1900 as a base year, an index of total energy consumption per unit of GNP rose to 116.8 in 1910 and was 116.2 in 1920 (Schurr and Netschert 1960, p. 524-525). The increasing importance of access to cheap bituminous coal around the turn of the last century is especially noticeable in an index of coal consumption per unit of GNP, which has a value of 100 in 1900, 125.7 in 1910, and 118.1 in 1920 (Schurr and Netschert 1960, p. 524-525).

A structural shift in industrial energy requirements apparently took place after 1920. While the index of total energy consumption per unit of GNP declined from 99.3 in 1930 to 74.7 in 1950, the index of coal input per unit of GNP fell from 80.1 to 38.5 over that same period (Schurr and Netschert 1960, p. 524-525). Access to coal was no longer important for manufacturing. Friscia (1970, p. 49) argues that there was a decreased demand for coal in industrial uses where increased productivity in fuel usage was an important cost concern. Industrial users substituted liquid and gas fuels for coal. An index of coal consumed by manufacturing per unit of manufacturing output stood at 100 in 1909, 81.6 in 1919, 54.5 in 1929, 38.5 in 1939, and 21.3 in 1954 (Schurr and Netschert 1960, p. 79).

Technological change reduced the advantages of being located near the bituminous mines in other ways as well. By-product coking reduced the cost of fuel for coke ovens remote from the industry's home in Connellsville in Fayette County, Pennsylvania, allowing for the use of poorer quality coal (Warren 1973, p. 115). This helped disperse the steel industry from around Pittsburgh. So, by 1920, the Pittsburgh mills had become the high cost producers. The mill cost at U.S. Steel's Pittsburgh works was $52.20 a ton compared to $42.80 in Chicago (Warren 1973, p. 178). Western Pennsylvania mills had remained competitive thanks to U.S. Steel's "Pittsburgh Plus" pricing scheme which set the price of steel anywhere in the country equal to the price in Pittsburgh plus the shipping cost from Pittsburgh. This enabled Pittsburgh steel mills to offer equal competition anywhere in the United States in terms of delivered price. Pittsburgh Plus pricing gave steel fabricators an incentive to locate in western Pennsylvania since steel prices were lowest in Pittsburgh. In 1920, a Pittsburgh structural steel fabricator could obtain steel for $7.60 a ton less than a Chicago competitor and was thus able to win contracts in Chicago (Warren 1973, p. 201).

Pittsburgh Plus pricing was in effect from 1909 to 1924 when the FTC ordered U.S. Steel to cease the practice of selling everywhere based on the Pittsburgh price. Immediately, a shift in finished steel production took place inside Pennsylvania itself. In 1920, 48.5 percent of total Pennsylvania production of rolled iron and steel occurred in Allegheny County and 6.2 percent in Lehigh and Northampton Counties in eastern Pennsylvania; in 1925, 43.7 percent was rolled in Allegheny County and 9.7 percent in those two Lehigh Valley counties (Warren 1973, p. 201).

IV. Summary

Coal mining did not harm the long run development of Pennsylvania's anthracite and bituminous regions. Coal mining is not associated with negative economic outcomes. Instead, from the Civil War through the Second World War, mining positively impacted the economies of the state's coal counties, with population density, a proxy for the standard of living, being significantly higher in these counties. As manufacturing production became more energy-intensive in the late nineteenth and early twentieth centuries, proximity to cheap coal became an important cost consideration. Fuel-intensive industries such as steel concentrated in the western Pennsylvania bituminous coal fields. With the declining importance to manufacturing of energy inputs in general and coal in particular after 1920, the economies of Pennsylvania's coal counties gradually came to look no different than the state's non-coal counties. The poor relative economic performance of the state's bituminous counties is a recent phenomenon and occurred long after coal mining ceased to be an important contributor to the region's economies. By 1980, mining of all kinds comprised just 2.4 percent of private employment in the coal regions of Pennsylvania.

References

Adams, Sean Patrick. *Old Dominion, Industrial Commonwealth: Coal, Politics, and Economy in Antebellum America*. Baltimore, MD: Johns Hopkins University Press, 2004.

Anonymous. "Notes and Memoranda." *Quarterly Journal of Economics* 3(4), July 1889, p. 497-499.

Aurand, Harold. "Diversifying the Economy of the Anthracite Region, 1880-1900." *Pennsylvania Magazine of History and Biography* 94(1), January 1970, p. 54-61.

Auty, Richard M. "Introduction and Overview." in R.M. Auty (ed.) *Resource Abundance and Economic Development*. Oxford: Oxford University Press, 2001, p. 3-16.

Beeson, Patricia E., David N. DeJong, and Werner Troesken. "Population Growth in U.S. Counties, 1840-1990." *Regional Science and Urban Economics* 31(6), November 2001, p. 669-699.

Billinger, Robert D. *Pennsylvania's Coal Industry*. Gettysburg, PA: Pennsylvania Historical Association, 1954.

Binder, Frederick Moore. *Coal Age Empire: Pennsylvania Coal and Its Utilization to 1860*. Harrisburg, PA: : Pennsylvania Historical and Museum Commission, 1974.

Bogen, Jules I. *The Anthracite Railroads: A Study in American Railroad Enterprise*. New York: Ronald Press, 1927.

Chandler, Alfred D. "Anthracite Coal and the Beginnings of the Industrial Revolution in the United States." *Business History Review* 49(2), Summer 1972, p. 141-181.

Chen, Kuan-I. *Agricultural Production in Pennsylvania, 1840 to 1950*. Ph.D. dissertation, Pennsylvania State University, 1954.

Chen, Kuan-I and Jerome K. Pasto. *Facts on a Century of Agriculture in Pennsylvania 1839 to 1950*. State College, PA: Pennsylvania State University College of Agriculture Agricultural Experiment Station, 1955.

Commonwealth of Pennsylvania. *Department of Environmental Resources Annual Report on Mining, Oil and Gas, and Land Reclamation and Conservation Activities*. Harrisburg, PA: Commonwealth of Pennsylvania, 1974.

Commonwealth of Pennsylvania. *Reports of the Inspectors of Mines of the Anthracite and Bituminous Coal Regions of Pennsylvania, for the Year 1891*. Harrisburg, PA: Edwin K. Meyers, 1892.

Convention of Iron Masters. *Documents Relating to the Manufacture of Iron in Pennsylvania*. *Published on Behalf of the Convention of Iron Masters, Which Met in Philadelphia, On the Twentieth of December, 1849*. Philadelphia, PA: The General Committee, 1850.

Coxe, Tench. *A Statement of the Arts and Manufactures of the United States of America for the Year 1810*. Philadelphia, PA: A. Cornman, 1814.

Cuff, Timothy. "Anthropometric History: What is It and What Can It Tell Us About Antebellum Pennsylvania?" *Pennsylvania History* 73(2), Spring 2006, p. 143-197.

DiCiccio, Carmen. *Coal and Coke in Pennsylvania*. Harrisburg, PA: Pennsylvania Historical and Museum Commission, 1996.

Dublin, Thomas and Walter Light. *The Face of Decline: The Pennsylvania Anthracite Region in the Twentieth Century*. Ithaca, NY: Cornell University Press, 2005.

Easterlin, Ricard A., "Interregional Differences in Per Capita Income, Population, and Total Income, 1840-1950", in*Trends in the American Economy in the Nineteenth Century*, Conference on Research in Income and Wealth (eds.), Princeton, NJ: Princeton University Press, 1960, p. 73-140.

Eavenson, Howard N. *The First Century and a Quarter of American Coal Industry*. Pittsburgh, PA: Privately Printed, 1942.

Edmunds, William E. *Coal Reserves of Pennsylvania: Total, Recoverable, and Strippable (January 1, 1970)*. Harrisburg, PA: Pennsylvania Geological Survey, 1972.

Ellison, Glenn and Edward L. Glaeser. "The Geographic Concentration of Industry: Does Natural Advantage Explain Agglomeration?"*American Economic Review* 89(2), May 1999, p. 311-316.

Fletcher, Stevenson Whitcomb. *Pennsylvania Agriculture and Country Life, 1840-1940*. Harrisburg, PA: Pennsylvania Historical and Museum Commission, 1955.

Florin, John. "The Advance of Frontier Settlement in Pennsylvania, 1638-1850: A Geographic Interpretation." Papers in Geography No. 14, Department of Geography, Pennsylvania State University, May 1977.

Friscia, August Blake. *Industrial Retardation and Economic Growth: A Case Study of Secular and Structural Change in the Bituminous Coal Industry of the United States, 1920-1960*. Ph.D. Dissertation, New York University, 1970.

Goldstein, G. S. and T. J. Gronberg, "Economies of Scope and Economies of Agglomeration." *Journal of Urban Economics* 16, 1984, p. 91-104.

Gylfason, Thorvaldur, Tryggvi Thor Herbertsson, and Gylfi Zoega. "A Mixed Blessing." *Macroeconomic Dynamics* 3, 1999, p. 204-225

Habakkuk. H. J. *American and British Technology in the Nineteenth Century: The Search for Labor-Saving Inventions*. Cambridge: Cambridge University Press, 1962.

Healey, Richard G. *The Pennsylvania Anthracite Coal Industry, 1860-1902: Economic Cycles, Business Decision-Making and Regional Dynamics*. Scranton, PA: University of Scranton Press, 2007.

Helsley, Robert W. amd William C. Strange, "Matching and Agglomeration Economies in a System of Cities." *Regional Science and Urban Economics* 20, 1990, p. 189-212.

Hoffman, John N. "Pennsylvania's Bituminous Coal Industry: An Industry Review." *Pennsylvania History* 45(4), October 1978, p. 351-363.

Hudson Coal Company. *The Story of Anthracite*. New York: Hudson Coal Company, 1932.

Jones, Chester Lloyd. *The Economic History of the Anthracite-Tidewater Canals*. Philadelphia, PA: University of Pennsylvania, 1908.

Knowles, Anne Kelly and Richard G. Healey. "Geography, Timing, and Technology: A GIS-Based Analysis of Pennsylvania's Iron Industry, 1825-1875." *Journal of Economic History* 66(3), September 2006, p. 608-634.

Lesley, J. P. *The Iron Manufacturer's Guide to the Furnaces, Forges and Rolling Mills of the United States*. New York: John Wiley, 1859.

Lindstrom, Diane. *Economic Development in the Philadelphia Region, 1810-1850*. New York: Columbia University Press, 1978.

Michaels, Guy. "The Long Term Consequences of Regional Specialization." London School of Economics and Political Science, Centre for Economic Performance Discussion Paper No. 766, December 2006.

Miller, Donald L. and Richard E. Sharpless. *The Kingdom of Coal: Work, Enterprise, and Ethnic Communities in the Mine Fields*. Philadelphia: University of Pennsylvania Press, 1985.

Mitchener, Kris James and Ian W. McLean. "The Productivity of U.S. States since 1880." *Journal of Economic Growth* 8(1), 2003, p. 73-114.

Papyrakis. Elissaios and Reyer Gerlagh. "Resource Abundance and Economic Growth in the United States". *European Economic Review* 51, 2007, p. 1011-1039.

Pennsylvania Department of Environmental Resources. *Annual Report on Mining Activities*. Harrisburg, PA: Pennsylvania Department of Environmental Resources, 1980.

Pennsylvania Department of Mines. *History of Pennsylvania Bituminous Coal*. Harrisburg, PA: Pennsylvania Department of Mines, 1955.

Powell, H. Benjamin. "The Pennsylvania Anthracite Industry, 1769-1976." *Pennsylvania History* 47(1), January 1980, p. 3-28.

Rappaport, Jordan and Jeffrey D. Sachs. "The United States as a Coastal Nation." *Journal of Economic Growth* 8(1), March 2003, p. 5-46.

Robinson, James A., Ragnar Torvick, and Thierry Verdier. "Political Foundations of the Resource Curse." *Journal of Development Economics* 79, 2006, p. 447-468.

Rosenthal, Stuart S. and William C. Strange, "The Determinants of Agglomeration." *Journal of Urban Economics* 50, 2001, 191-229.

Ruggles, Steven, Matthew Sobek, Trent Alexander, Catherine A. Fitch, Ronald Goeken, Patricia Kelly Hall, Miriam King, and Chad Ronnander. *Integrated Public Use Microdata Series: Version 4.0*. Minneapolis, MN: Minnesota Population Center, 2008.

Sachs, Jeffrey D. and Andrew W. Warner. "The Big Push, Natural Resource Booms and Growth." *Journal of Development Economics* 59, 1999, p. 43-76.

Sachs, Jeffrey D. and Andrew W. Warner. "The Curse of Natural Resources." *European Economic Review* 45(4-6), May 2001, p. 827-838.

Schaefer, Donald Fred. *A Quantitative Description and Analysis of the Growth of the Pennsylvania Anthracite Coal Industry 1820 to 1865*. New York: Arno Press, 1977.

Schurr, Sam H. and Bruce C. Netschert. *Energy in the American Economy, 1850-1975: An Economic Study of its History and Prospects*. Baltimore, MD: Johns Hopkins University Press, 1960.

Seaman, Ezra C. *Supplement No. 11 to Essays on the Progress of Nations in Productive Industry, Civilization, Population, and Wealth*. New York: Baker and Scribner, 1848.

Spohrer, George A. "The Knox Mine Disaster: The Beginning of the End." *Proceedings and Collections of the Wyoming Historical and Geological Society* 1984, p. 124-145.

Taussig, F. W. "The Iron Industry in the United States." *Quarterly Journal of Economics* 14(2), February 1900, p. 143-170.

Thorndale, William and William Dollarhide. *Map Guide to the U.S. Federal Censuses, 1790-1920*. Baltimore, MD: Genealogical Publishing, 1987.

Tucker, George. *Progress of the United States in Population and Wealth in Fifty Years As Exhibited by the Decennial Census from 1790 to 1840*. New York: Press of Hunt's Merchant's Magazine, 1855.

Warren, Kenneth. *Bethlehem Steel: Builder and Arsenal of America*. Pittsburgh, PA: University of Pittsburgh Press, 2008.

Warren, Kenneth. *The American Steel Industry 1850-1970: A Geographical Interpretation*. Oxford: Clarendon Press, 1973.

Wolensky, Robert P., Kenneth C. Wolensky, and Nicole H. Wolensky. *The Knox Mine Disaster: The Final Years of the Northern Anthracite Industry and the Effort to Rebuild a Regional Economy*. Harrisburg, PA: Pennsylvania Museum and Historical Commission, 1999.

Wright, Gavin. "The Origins of American Industrial Success, 1879-1940." *American Economic Review* 80(4), September 1990, p. 651-668.

Wright, Gavin and Jesse Czelusta. "The Myth of the Resource Curse." *Challenge* 47(2), March/April 2004, p. 6-38.