Tight Labor Markets and the Demand for Education: Evidence from the Coal Boom and Bust [*]

by

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Abstract

Human capital theory predicts that individuals acquire less schooling when the returns to schooling are small. To test this theory, we study the effect of the coal boom in Appalachia on high school enrollments. During the 1970s, a boom in the coal industry increased the earnings of high school dropouts relative to graduates. During the 1980s, the boom subsided and the earnings of high school dropouts declined relative to graduates. We find that high school enrollment rates in Kentucky and Pennsylvania declined considerably in the 1970s and increased in the 1980s in coal-producing counties relative to counties without coal.

I. Introduction

A simple model of human capital predicts that increases in the wages of workers with low education relative to workers with high education will reduce investments in schooling because the returns to additional years of schooling are diminished. In this paper, we exploit a particularly unique opportunity to study the effect of a decrease in the wage gap between high school dropouts and high school graduates on high school enrollment by studying the coal boom and bust of the 1970s and 1980s. During the 1970s, the OPEC oil embargo drove up the price of coal and generated an enormous boom in the coal economy, substantially increasing demand for coal miners in rural Appalachia. Because coal miners were largely low-skilled workers, this increased the earnings of high school dropouts relative to high school graduates. During the 1980s, the boom reversed into a bust, decreasing the earnings of high school dropouts relative to high school graduates. We study the effect of the coal boom and bust on high school enrollment in Kentucky and Pennsylvania. These states contain coal-producing regions of Appalachia that were particularly affected by the boom and bust. By comparing changes in high school enrollment in coal-mining counties relative to counties without coal-mining during this time period, we can estimate the effect of the coal shocks on human capital investment.

An important feature of the coal boom is that it lasted for many years, generating a relatively long-term change in the wage differential between high school dropouts and high school graduates. The effect of a change in demand for low-skilled workers on high school enrollment or completion should depend on how long that change is expected to last. Students presumably compare their income stream for the case in which they stay in school to the one in which they drop out and enter the labor force. A transitory change in wages for low-skilled workers will obviously have a much smaller affect on the income stream of dropouts than a long-

term one. The distinction between the effect of transitory and long-term changes in the earnings

of low-skilled workers is an important one in the context of current policy debates. There have

been numerous proposals to increase the earnings of low-skilled workers through the creation of

a public-sector jobs program, wage subsidies for low-skilled workers or changes in the minimum

wage. The enactment of these policies could generate very long-term changes in the earnings of

low-skilled workers. It is therefore important to appreciate what sort of impact such policies

might have on the educational attainment of students from low-income populations.

II. Economic Conditions and Human Capital Investment

This section considers the classical model of human capital investment as described in

Mincer (1958) and Becker (1964). The decision to drop out of high school will depend on the

wages of high-school graduates, w_{gt} , (where w_{gt} is the earnings of a high school graduate at

time t) and dropouts, w_{dt} . If person j drops out of high school, the discounted value of the flow

of earnings is:

(1) $$E_{jd} = \sum_{t=0}^{T} \frac{w_{dt}}{(1+\rho_j)^t} ,$$

where ρ_j is the discount rate of person j. If instead person j remains in school k more years to

complete high school, the present value of the flow of earnings of person j is:

(2) $$E_{jg} = \sum_{t=k}^{T} \frac{w_{gt}}{(1+\rho_j)^t} .$$

Because public education is free, the student will complete school if $E_{jg} > E_{jd}$:

(3) $$\sum_{t=k}^{T} \frac{(w_{gt} - w_{dt})}{(1+\rho_j)^t} - \sum_{t=0}^{k-1} \frac{w_{dt}}{(1+\rho_j)^t} > 0 .$$

The first term in equation (3) reflects the return to a high school degree, the positive wage differential between high school graduates and high school dropouts. The second term in equation (3) reflects the opportunity cost of a high school education. If the student remains in high school and graduates, he or she forgoes those k years of earnings. If the higher earnings associated with a high school degree are sufficient to reimburse the student for the opportunity cost of remaining in high school, the student will complete high school.

We now consider how various shocks to the local labor market will affect the decision to remain in school. First consider a shock that that raises the wages for both high school dropouts and high school graduates by the same amount. While this will have the effect of increasing the opportunity cost of a high school degree, it will not change the wage differential between graduates and dropouts. This might induce some students, particularly those with very high discount rates, to drop out of high school, but it should not have a particularly large effect on high school enrollments. Now consider a transitory shock that increases demand for low-skilled workers. Such a shock will temporarily raise the wages of high school dropouts relative to high school graduates. This increases the opportunity cost of a high school degree, and may decrease the wage gap between graduates and dropouts for the first year or so of work. A temporary shock, however, will have a negligible effect on the return to a high school degree calculated over a student's entire working life. Again, enrollments should be relatively unaffected. In order for a local labor market shock to have a substantial effect on high school enrollment, it must generate a *long-term* increase in the wages of dropouts relative to graduates. Such a shock will both increase the opportunity cost of a high school degree and reduce the return to a high school degree by narrowing the wage gap between dropouts and graduates for a substantial period of time.

There are a number of empirical studies that have analyzed the effect of economic conditions on educational attainment and therefore potentially test the predictions from this simple theoretical model. Several studies examine the effect of changes in the unemployment rate on high school dropout rates. To the extent that changes in unemployment rates tend to affect low-skilled workers more than high-skilled workers, it is possible to interpret a reduction in the unemployment rate as a flattening of the education-wage gradient.

Duncan (1965) conducted a very early study of the relationship between unemployment and dropout rates. She used the 1960 Census to calculate cohort-specific high school completion rates for men from 1902 to 1956. She found that a higher national unemployment rate at the time a cohort was of high school age increased the fraction of the cohort that remained in school. Rumberger (1983) used the first wave of the National Longitudinal Survey of Youth (NLSY79) to study the decision to drop out of high school. While he found a higher unemployment rates reduces the probability of dropping out among black and Hispanic males, he found it increases the probability of dropping out among white males. Both the Duncan and Rumberger studies potentially suffer from omitted variable bias, Duncan's from unobserved national shocks and Rumberger's from unobserved local characteristics.

In contrast, Rees and Mocan (1997) analyzed panel data on district-level high school dropout rates for New York State from 1978-87. Using a fixed-effects specification, they controlled for district-specific and year-specific unobserved characteristics. They found that for a district with a dropout rate at the state average, a 1 percentage point increase in the county unemployment rate decreases the dropout rate by 2 percent. One drawback of the fixed-effects approach used by Rees and Mocan is that it relies on short-term variation in the unemployment

4

rate within district for identification. We expect such transitory changes in economic conditions to have relatively small effects on the dropout rate.

Findings of two studies are consistent with the prediction that long-term increases in the wages of low-skilled workers relative to high-skilled workers should high school completion. Neumark and Wascher (1995) studied the effects of minimum wage increases using state-level panel data from 1977-89. They found that, controlling for state and year fixed-effects, increases in the minimum wage decrease school enrollment among teenagers. Goldin and Katz (1997) found that states with a high fraction of employment in manufacturing had lower levels of high school completion in 1910 and smaller increases in high school completion between 1910 and 1928. They argued that because most manufacturing jobs did not require a high school diploma, students in these states faced a lower return to a high school degree.

III. The Coal Boom and Bust

In this section, we describe the coal boom and bust of the 1970s and 1980s and the impact on the coal-mining areas of Kentucky and Pennsylvania. The Appalachian regions of these states have traditionally been relatively poor and also very dependent on the coal economy. The coal boom and bust also had large effects on coal-producing counties in Ohio and West Virginia, which we explore in related studies.[1]

In Figure 1, we plot the real price of coal over time, as well as the fraction of earnings in the two states attributed to mining. We can see that until 1969 the price of coal was relatively stable. Regulatory changes caused the coal price to increase 28 percent between 1969 and 1970, and the OPEC oil embargo caused the coal price to increase 44 percent between 1973 and 1974. These price increases generated a tremendous boom in the coal economy. In Kentucky, the

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[1] See Black, Daniels and Sanders (2002) and Black, McKinnish and Sanders (2003). We were unable to obtain adequate high school enrollment information on Ohio and West Virginia to include them in the current study.

fraction of earnings from mining more than tripled from about 3 percent to more than 9 percent

between 1969 and 1977. In Pennsylvania, the fraction of earnings from mining doubled from

roughly 1 percent to more than 2 percent between 1969 and 1977. In the graph, we can see that

both the price of coal and coal earnings stabilized for the period from 1978 and 1982. Starting

around 1982, the coal economy busted. The bust occurred due to a drop in the price of coal, as

well as the opening of alternative mines in the western United States and the automation of the

mining process, which decreased demand for low-skilled coal miners.

These coal shocks were not felt equally in all counties in Kentucky and Pennsylvania.

Some counties in these two states sit on major coal seams and benefited tremendously from the

coal boom.[2] More than half of the counties in this region, however, have almost no coal

reserves, and were largely unaffected by the coal boom and bust.

In Figure 2, we demonstrate the effect of the coal shocks on two coal-rich counties. We

plot the ratio of county per capita personal income to per capita personal income in the U.S.

between 1969 and 1993 for a very coal rich county in both Kentucky and Pennsylvania. In 1969,

Pike County, Kentucky starts with per capita income that is only 56 percent of national per

capita income. During the coal boom, this figure rises dramatically to 90 percent in 1980, and

then plummets back down to 63 percent of national per capita income by 1988. A similar trend

exists for Armstrong County, Pennsylvania.

In Table 1, we compare the characteristics of coal mining workers to all workers in our

two states in 1970 and 1990. From the table, we see that coal employment was predominantly

low skilled. In 1970, 45.2 percent of coal workers had less than eight years of education and a

full 68.7 percent had less than a high school education. By comparison, in 1970, only 18.0

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[2] There is one large seam in western Kentucky that is part of the Illinois coal basin, the very large Appalachian basin
that runs through western Pennsylvania and eastern Kentucky, and one other seam in eastern Pennsylvania.

percent of all workers had less than eight years of education and 41.3 percent had less than a

high school education. Even though education levels had increased overall by 1990, coal

workers in 1990 were still more likely to be low education than workers in general.

Because the coal industry employed primarily low-skilled workers, the coal boom of the

1970s should have raised the earnings of high school dropouts relative to high school graduates.

Likewise, the coal bust of the 1980s should have lowered earning of high school dropouts

relative to graduates. To confirm these effects, we use Census data from 1970, 1980, and 1990

to compare the changes in wages for high school dropouts and high school graduates between

coal-mining areas and non-coal mining areas.[3]

Unfortunately, the Public Use Microdata Samples (PUMS) data do not identify county of

residence in rural areas, only county groups with populations of at least 250,000 in 1970 and

with populations of 100,000 in 1980 and 1990. Many of these county groups overlap areas that

are both rich and poor in coal reserves. We divide the county groups in Kentucky and

Pennsylvania into those with less than 0.5% of employment in coal and those with more than 3%

of employment in coal.[4] County groups with between 0.5% and 3% of employment in coal are

removed from the sample. Using civilian male workers ages 25 to 40 with at least a 10th grade

education but no more than a high school degree we estimate the following regression using on

the 1970 and 1980 PUMS:

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[3] Data from the Decennial Censuses are the only data suited to analyze wages by education level in coal-producing
areas. Because coal-producing areas are rural, sample sizes in most available micro-level panel data sets are
extremely small. County-level economic data like that used below in the regression analysis do not contain wage
information or information on earnings by education level.
[4] The final sample from all three Census years of civilian male workers ages 25-40 with at least a 10th grade
education but no more than a high school degree contains 5,849 workers in areas with at least 3% of employment in
coal mining and 75,914 workers with less than 0.5% employment in coal mining. 15,571 workers that live in areas
with 0.5-3% of employment in coal-mining are dropped from the sample. Unfortunately, because the county groups
change over time, counties in the <.5% employment group and counties in the >3% employment group change from
Census to Census. Furthermore, because 1970 county groups cross state lines, the sample includes workers in 1970
from outside of Kentucky and Pennsylvania.

$$(4) \quad Wage_i = \sum_{j=10}^{12} \beta_{1j} d(j)_i + \sum_{j=10}^{12} \beta_{2j}[d(j)_i * CoalArea_i] + \sum_{j=10}^{12} \beta_{3j}[d(j)_i * d80_i]$$

$$+ \sum_{j=10}^{12} \beta_{4j}[d(j)_i * d80_i * CoalArea_i] + X\beta_5 + \varepsilon_i$$

where *Wage* is the hourly wage, *d(j)* is an indicator for completing *j* years of education, *d80* is an

indicator for 1980, *CoalArea* is an indicator for residence in a county group with at least 3% of

employment in coal mining, and *X* contains worker age and race indicators (white, black).[5] The

coefficient β_{4j} is therefore a differences-in-differences estimate of the effect of the coal boom on

the wages of civilian male workers ages 25-40 with *j* years of education. Specifically β_{4j} gives

the change in wage of workers with *j* years of education between 1970 and 1980 in coal-mining

areas relative to areas without coal mining.

The results from equation (4) are reported in the first column of Table 2. Consistent with

a boom in the coal economy, the wages increase in coal-mining areas relative to areas without

coal mining between 1970 and 1980 for all three education groups, but the wages increase more

for high school dropouts than high school graduates. Relative wages increase by \$3.85 for

workers with just a 10th grade education, increase \$1.76 for workers with just an 11th grade

education, and increase \$1.08 for workers with a high school degree. Therefore, we see

evidence that the coal boom reduces the wage differential between high school dropouts and

high school graduates, flattening out the education-wage gradient.

The analogous regression is estimated for the bust period from 1980 to 1990 and reported

in column 2 of Table 2. As is consistent with a bust in the coal economy, the wages decrease in

coal-mining areas relative to areas without coal mining between 1980 and 1990 for all three

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[5] The wage measure is total wage and salary earnings divided by hours of work, obtained by multiplying weeks worked last year by average number of hours worked per week. The 1970 PUMS only reports hours per week and weeks of work as intervals. We use the median value of each interval, obtained using the 1980 PUMS. Wage observations below 0.20 and above 100 are removed from the sample.

education groups, but the wages decrease more for high school dropouts than high school graduates. Wages decrease by $2.95 for workers with just a 10th grade education, decrease $1.66 for workers with just an 11th grade education and decrease $1.10 for workers with a high school degree. The bust almost perfectly erases the wage gains obtained during the boom. In doing so, the bust widens the wage differential between high school dropouts and graduates, increasing the education-wage gradient.

The coal boom and bust were relatively long-term shocks, reducing or increasing the wage differential between dropouts and graduates for many years. Furthermore, residents of coal-mining areas during the boom would likely have perceived that the coal boom was a long-term shock, because they would have observed the enormous levels of capital investment being made to expand existing mines and open many new ones.[6] As the coal boom and bust were long-term exogenous shocks to the return to a high school degree, they are well suited for testing the basic predictions of the human capital model.

IV. Graphical Analysis of High School Enrollment

We expect to see high school enrollment rates in counties with coal mining to decrease during the boom years in the 1970s relative to those in counties without coal mining. We expect to see high school enrollment rates for the coal-mining counties to increase during the bust years of the 1980s relative to enrollment rates for counties without coal mining. Because coal miners are almost exclusively male, we would expect to see these trends for male students much more

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[6] The capital investors also perceived that the shift in demand for coal was long-term. This perception was based on the shift to coal-based electricity production. Electricity can be produced from several fuels but because of interfuel substitution costs "it would take a major, enduring change in relative fuel prices to alter [fuel choice]" (Harvey 1986). Between 1973 and 1982, coal largely replaced gas and oil as a source of electricity production. As a result, the demand for coal itself has remained high, while alternative mines in the West and automated mining technology have reduced the demand for Appalachian coal workers. These factors that reduced the demand for Appalachian coal miners would have been largely unanticipated by miners during the boom, so they likely perceived the boom to be more permanent than it was.

9

so than female students. Unfortunately, gender-specific data on high school enrollment or graduation at the county level are not available for our states and time-period of interest, so we are unable to perform gender-specific analysis.

We use state administrative data on annual public school enrollment by grade level for all counties in Kentucky and Pennsylvania from 1971 to 1990. We cannot calculate enrollment rates by individual grade level because we do not have annual county-level population counts by age but only 5-year age group. We therefore calculate the high school enrollment rate as the total enrollment in grades 9 to 12 divided by the population age 15 to 19, and the grade school enrollment rate as the total enrollment in grades 5 to 8 divided by the population age 10 to 14. We would prefer to use ages 15 to 18 in the denominator of our high school enrollment rate and ages 11 to 14 in the denominator of our grade school enrollment rate, but annual county-level population numbers are only available in these 5-year age groups. In general, this should not affect our analysis unless the coal boom induces migration of 19 year-old males who have already completed high school in other states or counties. We address this point later in the paper.

Our strategy is to compare changes in high school enrollment rates over time in counties with large deposits of coal reserves to those without coal.[7] To this end, we divide counties into three groups. Counties with at least one billion tons of coal reserves are considered "Big Coal" counties. Counties with between 100 million and one billion tones of coal reserves are considered "Medium Coal" counties, and counties with less than 100 million tons of coal reserves are considered "Low Coal" counties. These cutoffs are somewhat arbitrary, but we

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[7] Information on county coal reserves was obtained from geological surveys conducted by each state We obtained coal reserve information for Kentucky from the Kentucky Geological Survey's Kentucky Coal Resources Information Database. For Pennsylvania, we used estimates from Edmunds (1972). See Black, Daniel, and Sanders (2002) for additional information.

generally observe considerable mining activity in counties with at least one billion tons while counties with less than 100 million tons have almost no mining activity.[8] We calculate annual aggregate high school and grade school enrollment rates for each of these three categories.

In Figure 3, we plot high school enrollment trends for Kentucky. Because coal-mining areas in Kentucky are largely rural, we only use counties that do not belong to a metropolitan statistical area, to avoid comparing rural coal-rich counties to urban non-coal counties. There are 17 Big Coal counties, 14 Medium Coal counties, and 71 Low Coal counties in the Kentucky sample. The first graph in Figure 3 plots high school enrollment rates for the Big Coal and Low Coal categories. We see that, as predicted, the Big Coal high school enrollment rate is decreasing relative to enrollment rates in Low Coal counties during the boom period from 1971-78. Figure 1 shows that the coal boom leveled off around 1978. After 1978, high school enrollment in Big Coal areas is increasing relative to enrollment in Low Coal areas. The second graph in Figure 3 compares the high school enrollment rate for Medium Coal counties to the rate for Low Coal counties. A similar pattern emerges in which the Medium Coal high school enrollment rate decreases relative to the Low Coal rate until 1978, after which the Medium Coal rate increases relative to the Low Coal rate.

It is possible that the coal boom could have increased the fraction of families in counties with coal reserves that were able to send their children to private school. This would generate a similar pattern in public high school enrollment rates to what we observe in Figure 3. If private school attendance explains the patterns observed in Figure 3, then we expect to see similar patterns in public grade school enrollment. In Figure 4, we repeat the analysis performed in

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[8] We could divide counties into groups based on their actual employment in mining, as we did in our wage analysis above. But this measure is less exogenous. Unobserved characteristics of the counties might have caused some to develop larger coal mining industries over time. Given that we have county-level measures of coal reserves, this is the preferred measure.

Figure 3, but for public school enrollment rates for grades 5 to 8. In stark contrast to Figure 3, we see that grade school enrollment rates are almost indistinguishable between the Big Coal, Medium Coal, and Low Coal counties.[9]

V. Instrumental Variables Analysis of High School Enrollment

Ideally, we would like to estimate the relationship between changes in the wage of high school dropouts and changes in high school enrollment, controlling for wages of high school graduates. Unfortunately, the necessary wage data are not available at the county level. We use the Regional Economic Information System (REIS) data provided by the Bureau of Economic Analysis. These data report annual county-level earnings and employment. We divide total real county earnings by county employment to obtain a measure of earnings per worker.

We begin with a baseline regression model of the form:

$$(5) \qquad FrHS_{cst} = \beta_0 + \beta_1 EarnPW_{cst} + \beta_2 FrGS_{cst} + (State_s * Year_t)\beta_3 + \varepsilon_{cst},$$

where $FrHS_{cst}$ is the logarithm of the fraction of residents age 15 to 19 enrolled in high school in county c in state s and year t. $EarnPW$ is the logarithm of earnings per worker. $FrGS$ is the logarithm of the fraction of residents age 10 to 14 enrolled in grades 5 to 8. $State_s$ is a vector of state indicators and $Year_t$ is a vector of year indicators. Because we are controlling for state-year effects, this purges the data of anything that varies over time at the state level.

Estimating equation (5) will likely produce biased results, because counties will differ in unobserved ways that affect both their economic well being and their tastes for education. For this reason, we estimate equation (5) in differences instead of in levels:

$$(6) \qquad \Delta FrHS_{ist} = \beta_O + \beta_1 \Delta EarnPW + \beta_2 \Delta FrGS + (State_s * Year_t)\beta_3 + \Delta\varepsilon_{ist},$$

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[9] A similar, although more modest, difference in trends between high school and grade school enrollment in coal-rich counties compared to counties without coal can be observed in data from Pennsylvania. These graphs are available upon request from the authors.

where $\Delta X_t = X_t - X_{t-1}$. Of course, in equation (6), changes in earnings per worker do not necessarily reflect long-term changes in the earnings of high school dropouts relative to high school graduates. We therefore make explicit use of the variation from the shocks to the coal economy, which we know does generate long-term changes in the wage differential between dropouts and graduates. We use an instrumental variables (IV) model to capture the changes in county earnings per worker that can be attributed to the coal shocks. Our first stage regression model is:

(7) $\Delta EarnPW_{ist} = \alpha_0 + \alpha_1 \Delta (CoalValue)_{ist} + \alpha_2 \Delta FrGS_{ist} + (State_s * Year_t)\alpha_3 + \mu_{ist}$.

Our instrument is the value of coal reserves in the county. The larger the amount of coal reserves in the county, the more mineable the county's coal and the more the county will profit from the coal boom. We use two different specifications of our instrument. The first is the logarithm of the amount of coal reserves multiplied by the change in the logarithm of the real price of coal. It is evident from Figure 1 that the changes in earnings lag slightly behind the changes in the price of coal, because it can take some time to open a new mine. Therefore, we include a lag of the value of coal reserves as well.

For our second specification of the instrument, we use three indicators for whether the county is a Big Coal, Medium Coal or Low Coal county. We then use three time-period indicators: one for the boom from 1970-77, another for the stable period at the peak from 1978-1982, and the last for the bust from 1983-1990. Our instruments are the interactions of these two sets of dummy variables. The second-stage regression then takes the form:

(8) $\Delta FrHS_{ist} = \gamma_0 + \gamma_1 \Delta Ear\hat{n}PW_{ist} + \gamma_2 \Delta FrGS_{ist} + (State_s * Year_t)\gamma_3 + \varepsilon'_{ist}$.

The predicted value of the change in *EarnPW* used in equation (8) reflects changes in earnings per worker that can be attributed to the coal boom and bust, therefore reflecting changes

13

in worker wages associated with a long-term increase in returns for low-skilled workers relative

to high-skilled workers. In contrast, much of the time-series variation in earnings per worker

captured in the differences regression in equation (6) will reflect relatively short-term

fluctuations in earnings opportunities. This short-term variation will have only a modest impact

on the total earnings stream of high school dropouts, and therefore have a relatively small effect

on the decision to leave high school. As a result, we expect our estimate of γ_1 to larger in

magnitude than β_1.

We report our results in Table 3. The first row reports the coefficient on earnings per

worker obtained by estimating the first-differences regression in equation (6) by OLS. The other

two rows report the estimates obtained using IV estimation with our two different instruments.

The first column reports the results for the entire sample. The OLS coefficient is small, positive

and insignificant. The OLS results indicate that there is no relationship between earnings per

worker and high school enrollment rates. This is consistent with our expectation that short-term

fluctuations in economic conditions have a relatively small effect on school enrollment

decisions.[10]

In the second row, we report the IV estimates we obtain using the coal price instrument.

The coefficient estimate is negative, large in magnitude, and highly significant. The coefficient

of -0.648 implies that a 10% increase in earnings per worker associated with the coal boom

reduces high school enrollment by 6.5%. This is a very large effect, but it must be remembered

that this is a 10% increase in earnings per worker associated with the coal shocks. In other

words, this 10% increase in earnings per worker most likely reflects an even larger increase in

earnings per working high school dropout. The partial F-statistic from the first-stage is reported

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[10] Similar results of small magnitude are obtained if we restrict the sample to counties with low coal reserves.

in brackets. The F-statistic of 22 indicates that the change in value of coal reserves is a strong

instrument for earnings per worker. In the final row, we use the interaction of coal reserve size

and time period indicators as the instrument. The coefficient estimate of -0.490 is somewhat

smaller than what was obtained with the first instrument, but still large and significant.

In the second column, we report the results we obtain using only the counties in

Kentucky. These results are very similar to those obtained for the full sample, suggesting an

elasticity in the range of –0.54 to –0.72. The similarity in the results is not surprising, because

Kentucky has many more counties than Pennsylvania, particularly once the MSA counties are

removed from the sample. Additionally, Kentucky has more "big coal" counties than

Pennsylvania. Therefore, the results for Kentucky and the results for Pennsylvania and Kentucky

combined should be relatively similar.

In the third column, we report results using only the counties in Pennsylvania.   The IV

results for Pennsylvania, while negative, are smaller and statistically insignificant.   It is

important to remove the MSA counties from the sample for Kentucky because the coal-

producing areas of Kentucky are overwhelmingly rural. The coal-producing areas of

Pennsylvania, however, are both rural and metropolitan so it is reasonable to estimate the model

including the MSA counties (with an MSA indicator in the model). The results of including the

MSA counties in the estimation for Pennsylvania are reported in the column 4. The results are

significant and indicate an elasticity in the range of -0.22 to -0.38.

While these results indicate a strong negative relationship between earnings per worker

and high school enrollment, there is one remaining issue that must be addressed. The coal boom

generated migration of workers into coal-producing areas. Because we divide high school

enrollment by the population age 15 to 19, the in-migration of 19 year olds who have already

completed high school would also cause a decrease in high school enrollment rates in coal-producing counties during the coal boom. The concern is that the change in the dependent variable, the high school enrollment rate, is being driven by an increase in the denominator due to economic migration. Therefore, in Table 4, we re-estimate our models using the level of high school enrollment rather than the enrollment rate, moving the measure of high school age population to the right hand side of the regression:

(10) $\Delta HS_{ist} = \beta_0 + \beta_1 \Delta EarnPW + \beta_2 \Delta FrGS + \beta_3 HSPop + (State_s * Year_t)\beta_4 + \Delta\varepsilon_{ist}$,

where HS is the logarithm of total enrollment in grades 9 to 12 and $HSPop$ is the logarithm of population age 15 to 19.

If our results in Table 3 are largely the result of changes in the population age 15 to 19, we expect to see a substantial change in our estimates when we move the population measure to the right-hand side of the regression. The coefficients in Table 4 are somewhat smaller in magnitude than those in Table 3, but overall the differences are modest. The results still suggest large effects of the coal shocks on high school enrollment. While the evidence is somewhat circumstantial because we cannot directly observe the characteristics of the coal migrants, it does not appear that our results are an artifact of economic migration.[11]

VI. Conclusions

By examining the effect of the coal boom and bust on high school enrollment in coal-producing areas of Kentucky and Pennsylvania, we estimate much larger effects of local economic conditions on school enrollment than what has previously been found in the literature. This is not surprising, as the coal shocks had long-term effects on the wage differential between

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[11] Additionally, Black, McKinnish, and Sanders (forthcoming) use the 1970, 1980, and 1990 PUMS to compare population growth for men and women between coal-mining county groups and county groups without coal-mining in the manner of the wage analysis performed in this paper. This analysis suggests that in-migration during the coal boom was much more prevalent among men in their 30s than men of high school age.

high school dropouts and high school graduates. Other studies have used the unemployment rate, a more indirect measure of the change in returns to a high school degree, and have often relied on shorter-term variation in economic conditions.

Our findings indicate that a 10 percent increase in the earnings of low-skilled workers that could decrease high school enrollment rates by as much as 5 to 7 percent, provided that the increase is viewed as a long-term change in earnings. Therefore, policies designed to improve the employment and earnings opportunities of low-skilled workers, such as public jobs programs, wage subsidies and minimum wage increases, could have the unanticipated effect of enticing more students to leave high school.

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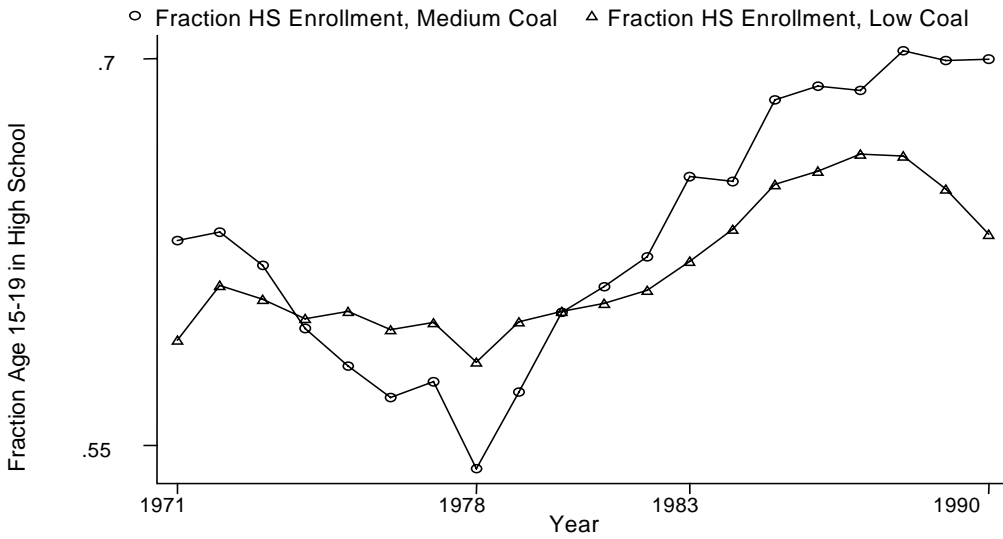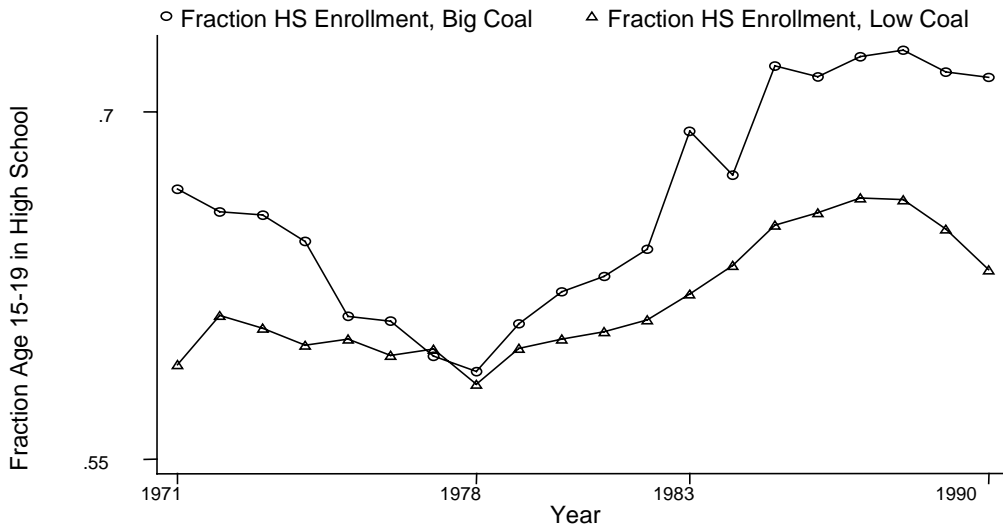
**Figure 1: Coal Prices and Fraction Earnings from Mining**

o Real Price of Coal   △ Earnings from Mining

Kentucky

o Real Price of Coal   △ Earnings from Mining

Pennsylvania

19
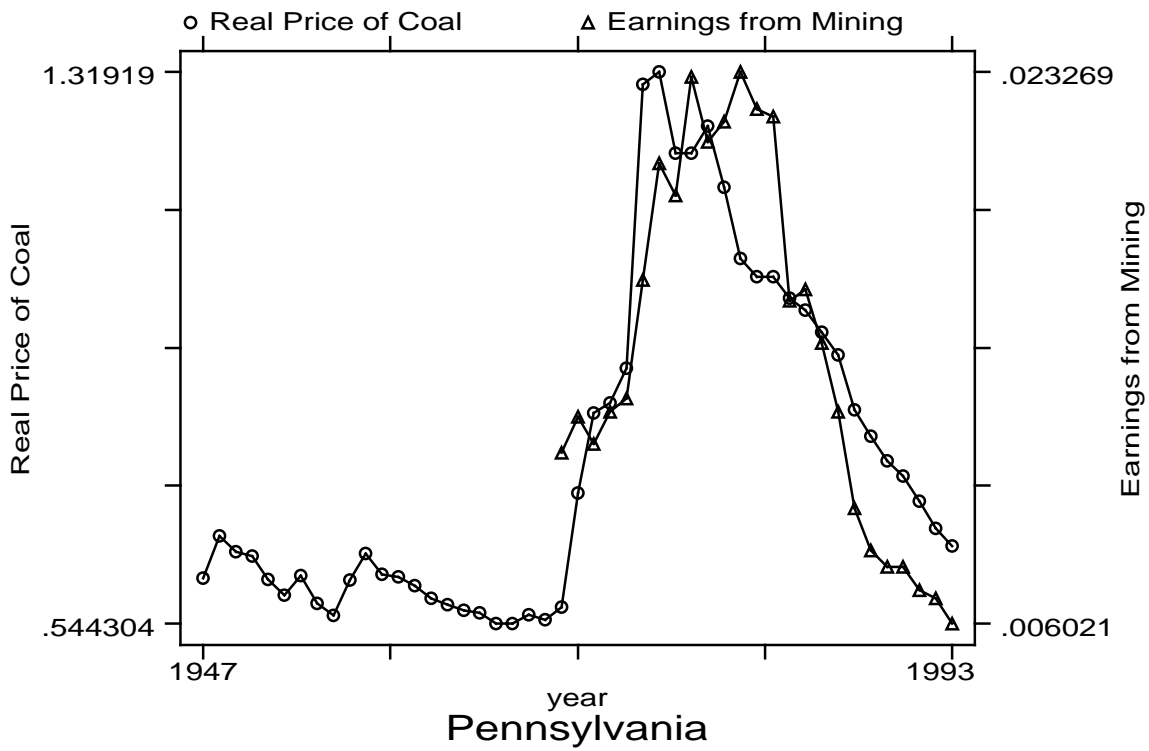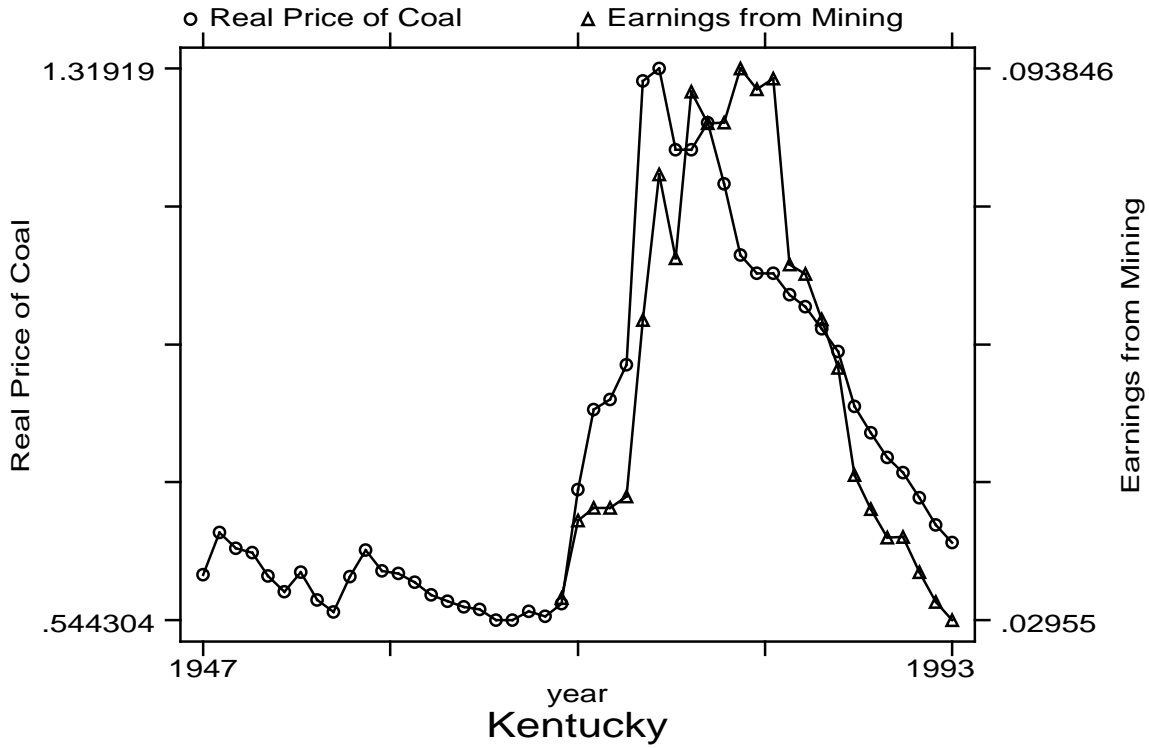
Figure 2: County Per Capita Income Relative to the U.S., Two Coal-Producing Counties, 1969 to 1993

Pike County, KY

Armstrong County, PA
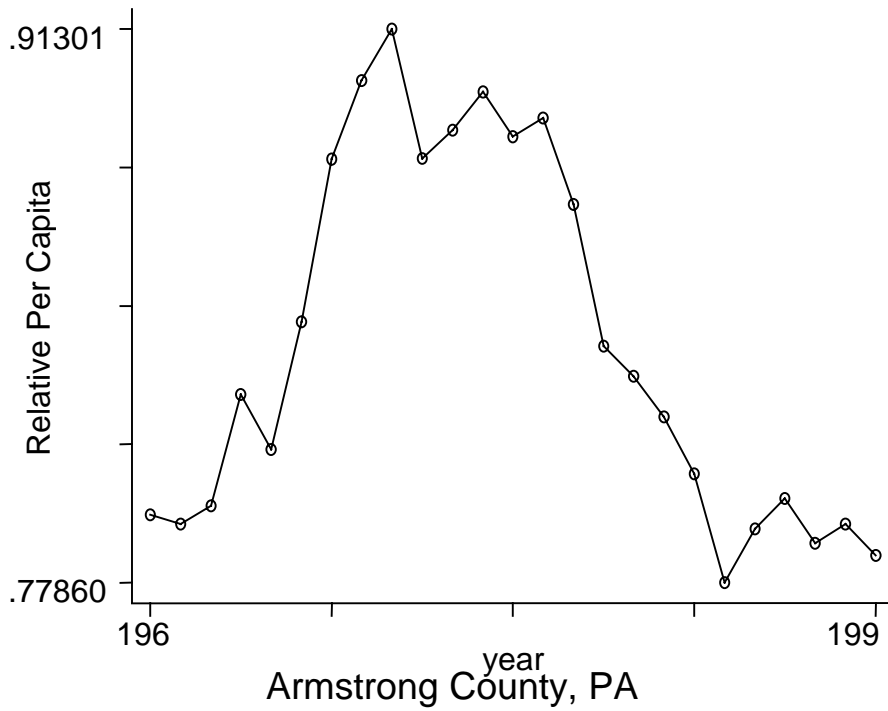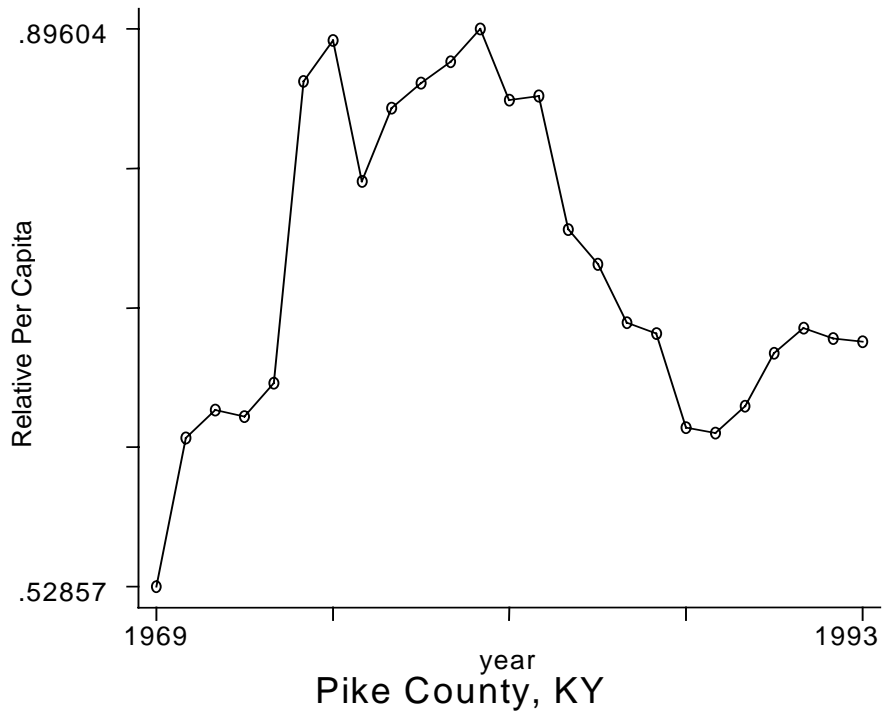
Figure 3: Kentucky High School Enrollment

Figure 4: Kentucky G5-G8 Enrollment

22
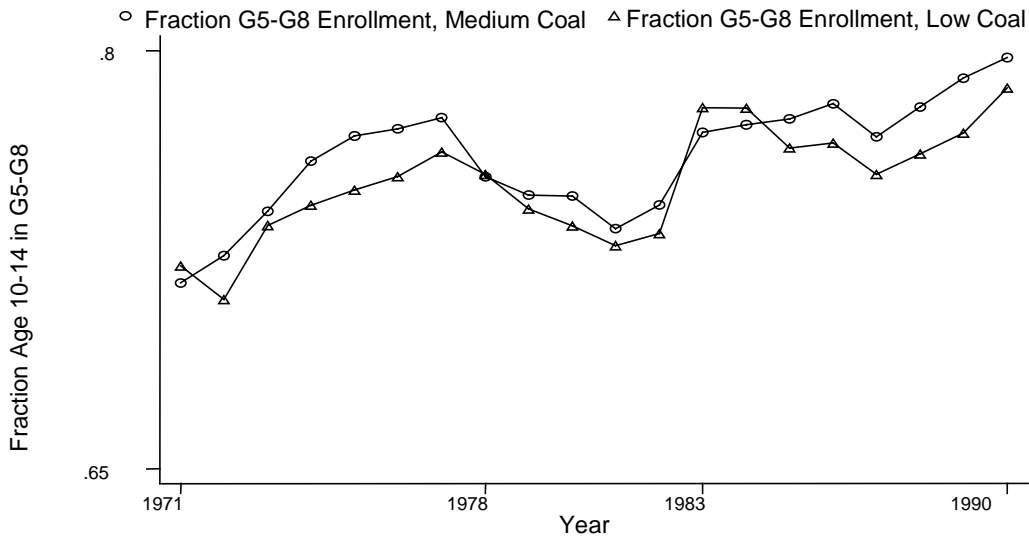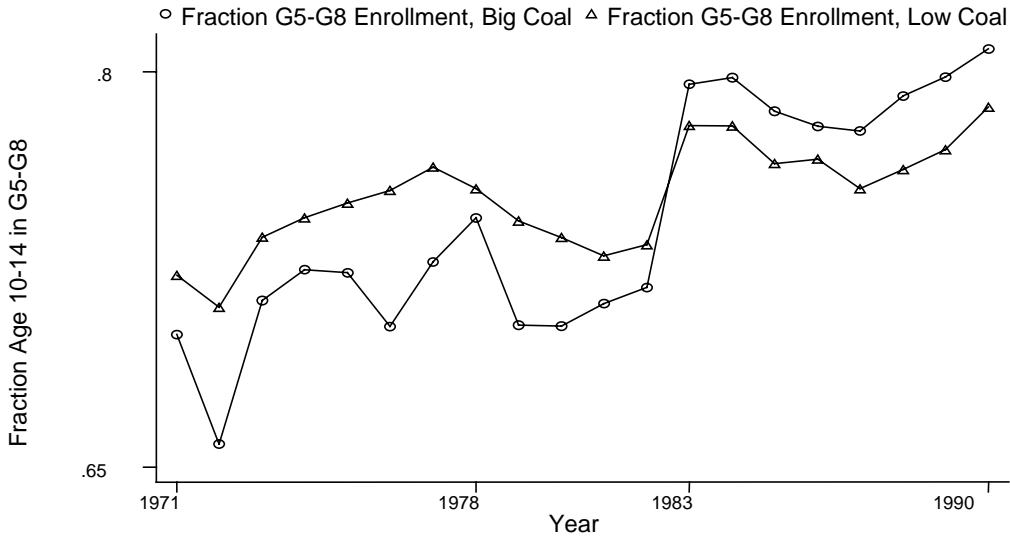
Table 1: Characteristics Coal Mining Workers in Kentucky and Pennsylvania: 1970 and 1990 Census Data

	Coal Workers 1970	All Workers 1970	Coal Workers 1990	All Workers 1990
Years of Schooling				
Less than 8 years	45.2%	18.0%	10.7%	4.3%
9 to 12 years, no diploma	23.5	23.3	21.1	14.3
High school graduate	24.7	37.0	48.1	39.8
Some College	4.6	10.5	14.5	23.4
College graduate	2.0	11.2	5.6	18.2

Notes: Calculations made using the 1970 and1990 Public Use Micro Samples (PUMS) from the 1970 and 1990 Censuses.

Table 2: Changes in the Education-Wage Gradient:
1970, 1980, and 1990 Census Data

	Wage Change from 1970 to 1980	Wage Change from 1980 to 1990
Change in county groups with at least 3% employment in mining relative to areas with less than 0.5% employment in mining:		
Workers with a 10th Grade Education	3.852 (1.343)	-2.952 (0.653)
Workers with an 11th Grade Education	1.764 (1.642)	-1.658 (0.623)
Workers with a High School Degree	1.078 (0.632)	-1.100 (0.231)
N	44,473	69,420

Notes: Wages for civilian men 25-40 years old with at least a 10th grade education but no more than a high school degree are calculated from the 1970, 1980, and 1990 PUMS. Workers in county groups in which at least 3% of employment is in coal mining are compared to those in which there is no more than 0.5% employment in coal mining. Regressions also control for age and race (black, white). Standard errors are reported in parentheses.

**Table 3: Effect of Earnings per Worker on Fraction Age 15 to 19
Enrolled in High School, 1972-90**

Regression Model	Kentucky and Pennsylvania	Kentucky Only	Pennsylvania Only	Pennsylvania with MSA Counties
First-Differences	0.003 (0.033)	0.003 (0.034)	0.024 (0.039)	0.009 (0.028)
IV Coal Price Instrument	-0.648** (0.179) [22.4]	-0.715** (0.209) [19.4]	-0.229 (0.230) [12.0]	-0.384* (0.192) [16.3]
IV Coal Seam Instrument	-0.490** (0.104) [13.3]	-0.544** (0.120) [12.4]	-0.205 (0.153) [13.0]	-0.220* (0.097) [7.7]
N	2622	1938	684	1273

Notes: Sample is all non-MSA counties in Kentucky and Pennsylvania. Dependent variable is the change in the logarithm of fraction of children ages 15 to 19 enrolled in grades 9 to 12. Table reports coefficient on change in the logarithm of earnings per worker. Regressions include controls for the logarithm of the fraction of children ages 10 to 14 enrolled in grades 5 to 8 and state-year effects (and an MSA dummy in column 4). Huber-White robust standard errors reported in parentheses. First-stage partial F-statistics reported in brackets. Coal Price instrument is the logarithm of the size of coal reserves multiplied by the change in logarithm of the real price of coal and it's one-year lag. Coal Seam instrument is indicators for size of coal reserves (less than 100 million tons, 100 million to 1 billion tons, more than 1 billion tons) interacted with indicators for time period (boom: 1972-77, peak: 1978-82, bust: 1983-90).* p-value<0.05 **p-value <0.01

Table 4: Effect of Earnings per Worker on Total High School Enrollment, 1972-90

Regression Model	Kentucky and Pennsylvania	Kentucky Only	Pennsylvania Only	Pennsylvania with MSA Counties
First-Differences	0.010 (0.033)	0.010 (0.034)	0.030 (0.037)	0.019 (0.026)
IV Coal Price Instrument	-0.555** (0.159) [22.0]	-0.587** (0.189) [18.9]	-0.219 (0.205) [12.1]	-0.293* (0.148) [16.2]
IV Coal Seam Instrument	-0.441** (0.098) [13.6]	-0.499** (0.116) [12.7]	-0.116 (0.119) [13.2]	-0.153 (0.081) [7.7]
N	2622	1938	684	1273

Notes: Sample is all non-MSA counties in Kentucky and Pennsylvania. Dependent variable is the change in the logarithm number of students enrolled in grades 9 to 12. Table reports coefficient on change in the logarithm of earnings per worker. Regressions include controls for the logarithm of the fraction of children ages 10 to 14 enrolled in grades 5 to 8, the logarithm of the population ages 15 to 19, and state-year effects (and an MSA dummy in column 4). Huber-White robust standard errors reported in parentheses. First-stage partial F-statistics reported in brackets. Coal Price instrument is the logarithm of the size of coal reserves multiplied by the change in logarithm of the real price of coal and it's one-year lag. Coal Seam instrument is indicators for size of coal reserves (less than 100 million tons, 100 million to 1 billion tons, more than 1 billion tons) interacted with indicators for time period (boom:1972-77, peak: 1978-82, bust: 1983-90).* p-value<0.05 **p-value<0.01